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FAA Technical Center
Atlantic City International Airport
N.J. 08405

Vertical Drop Test of a Metro III Aircraft

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Final Report

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NOTICE

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16. Abstract

A commuter category Fairchild Metro III fuselage and wingbox assembly was subjected to a vertical impact test at the Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, NJ. The purpose of the test was to measure the structural response of the fuselage, floor, cabin furnishing (including standard and modified seats) and anthropomorphic dummies. The test was conducted to simulate the potentially survivable impact conditions of an actual crash. The airframe was dropped from 11.2 feet and impacted at a velocity of 26.32 feet per second (ft/sec). The test weight simulated an airplane configuration that was approximately 1,450 pounds less than the maximum zero fuel weight (13,100 pounds) of the airplane with a 14,100-pound maximum takeoff weight.

Acceleration, load and deflection data were collected throughout the test. Instrumentation were located on the fuselage, floor, seats, and within the anthropomorphic test dummies. The vertical impact test resulted in peak accelerations of gravity (g) ranging from 40g to 60g throughout the airframe.

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EXECUTIVE SUMMARY

A commuter category Fairchild Metro III fuselage and wingbox assembly was subjected to a vertical impact test at the Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, NJ. The purpose of the test was to measure the structural response of the fuselage, floor, cabin furnishing (including standard and modified seats) and anthropomorphic dummies. The test was conducted to simulate the potentially survivable impact conditions of an actual crash. The airframe was dropped from 11.2 feet and impacted at a velocity of 26.32 feet per second (ft/sec). The test weight simulated an airplane configuration that was approximately 1,450 pounds less than the maximum zero fuel weight (13,100 pounds) of the airplane with a 14,100-pound maximum takeoff weight.

Acceleration, load and deflection data were collected throughout the test. Instrumentation were located on the fuselage, floor, seats, and within the anthropomorphic test dummies. The vertical impact test resulted in peak accelerations of gravity (g) ranging from 40g to 60g throughout the airframe.

INTRODUCTION

OBJECTIVE.

This report presents the results of an airplane vertical impact test conducted at the Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, NJ. This test entailed dropping a Fairchild Metro III fuselage and wingbox assembly from a vertical height of 11.2 feet, resulting in a impact velocity of 26.32 feet per second (ft/sec). The airframe was configured to simulate a typical flight configuration, including seats, simulated occupants, and cargo. The structural response of the airframe, seats, and anthropomorphic dummies was measured throughout the test. The data collected in this test and future tests will supplement the existing basis for improved seat/restraint systems for commuter category Federal Aviation Regulation (FAR PART 23) airplanes.

BACKGROUND.

The FAA Technical Center is involved in aircraft structural research focusing on enhancing occupant safety in a post-crash environment. In those accidents where the fuselage maintains a habitable space, the energy absorption characteristics of the airframe structure and the structural performance of the seat/restraint system are paramount to occupant safety.

The test described in this report is one in a series of tests to understand the impact response characteristics of Part 23 commuter category airplane airframes, and floor structures, including seats, seat attachments, and occupant restraint systems.

DESCRIPTION

TEST FACILITY.

The Technical Center drop test facility (figure 1) is comprised of two 50-foot vertical steel towers connected at their tops by an elevated platform. An electrically powered winch, mounted on the tower, is controlled from the base of one of the tower legs. The tower and lifting capacity of the winch is rated at 25,000 pounds. Attached to the winch is a reeved hoisting cable which is used to raise the test article. A sheave block assembly hanging from the free end of the reeved cable is engaged to a solenoid operated release hook. The release hook is connected to the airframe by a cable/turnbuckle sling assembly. Located directly below the winch cable assembly and between the tower legs is a 15- by 36-foot wooden load measurement platform which rests upon I-beams.

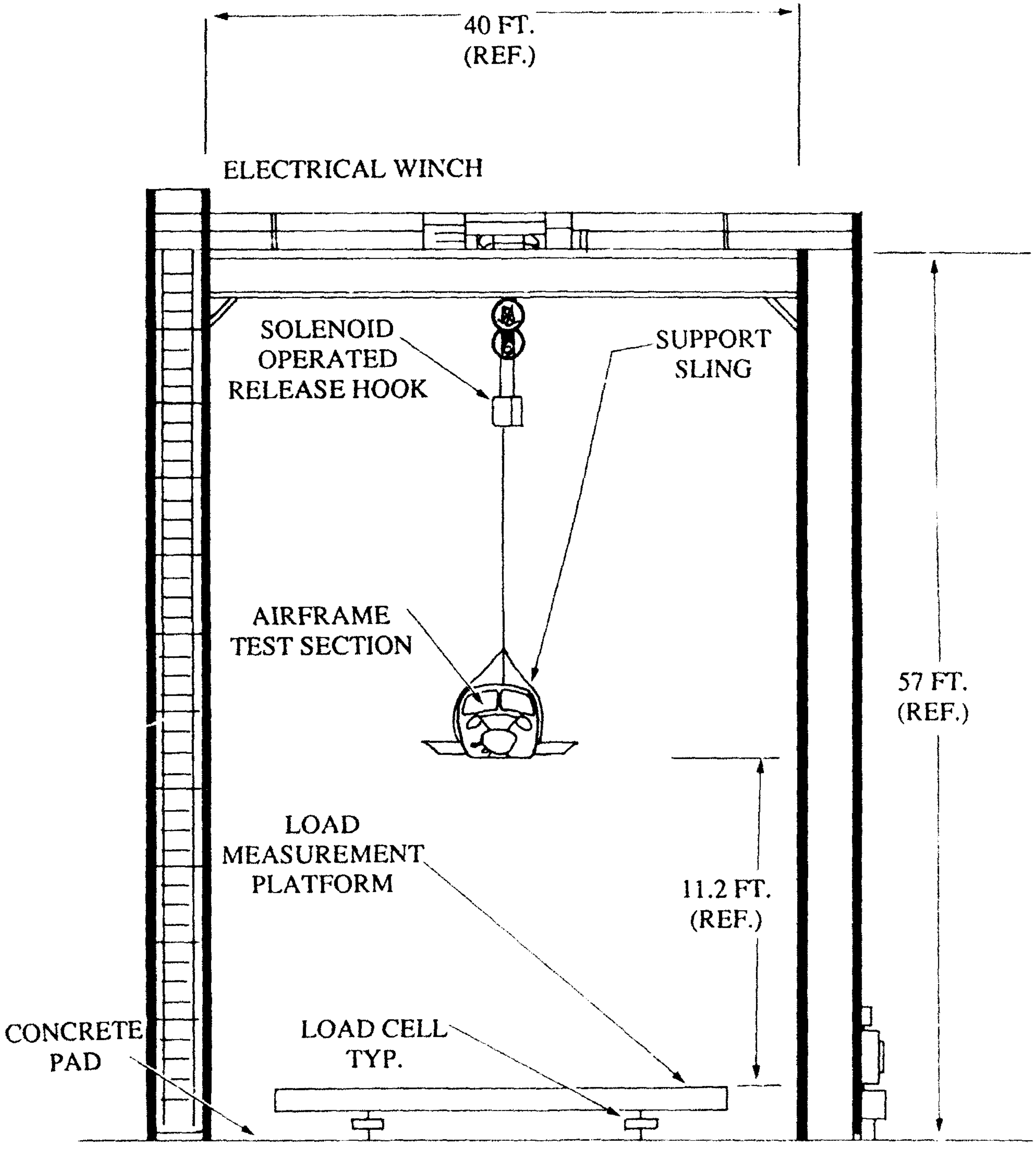


FIGURE 1. DROP TEST FACILITY

TEST ARTICLE.

The test article was a Fairchild Metro III. The airplane is an all metal, low wing aircraft built by Fairchild Aircraft Company of San Antonio, Texas.

The specifications of the Metro III (figure 2) are:

	TYPE CERTIFICATE DATA	TEST CONFIGURATION
Length overall	59.3 ft.	55.0 ft.
Height overall	16.8 ft.	6.0 ft.
Wing Span	57.0 ft.	N/A
Wing area	309 ft.	N/A
Maximum takeoff weight	14,500 lbs.	N/A
Weight empty	8,737 lbs.	N/A
Maximum landing weight	14,000 lbs.	N/A
Test weight	N/A	7347 lbs.

(Note that the above test weights are measured weights, while the weight in table 1 is the estimated drop weight.)

The center of gravity is at fuselage station 258.

The Metro III drop test article is a less than complete airplane in that the wing (and fuel mass), landing gear, and empennage structure are not included. A review of the geometry of the airplane found that the engines/nacelles are below the lower moldline of the fuse lage structure. It has been assumed due to the geometry of the airplane that the engines/nacelles and the center wing structure would contact the ground prior to or simultaneously with the fuselage structure. Thus the inertial loads from the engines/nacelles and the wing (and fuel mass) would be reacted directly by the ground and not transferred into the fuselage structures therefore, their mass was not simulated in the test.

The airplane was configured to provide a representative high density load distribution to the lower fuselage structure. The test weight simulated an airplane configuration that was approximately 1,450 pounds less than the maximum zero fuel weight (13,100 pounds) of the airplane with a 14,100 pound maximum takeoff weight.

The test article shown in figure 1 includes a complement of seats and dummies to represent the occupant loading and distribution.

Prior to the test, the airframe test specimen was leveled with ballast then raised to the desired height of 11.2 feet. The total test airframe weight was 7,347 pounds for the drop test. The aircraft center of gravity was located at body station 258 (258 inches aft of the nose). The airframe vertical velocity upon impact was approximately 26.32 ft/sec.

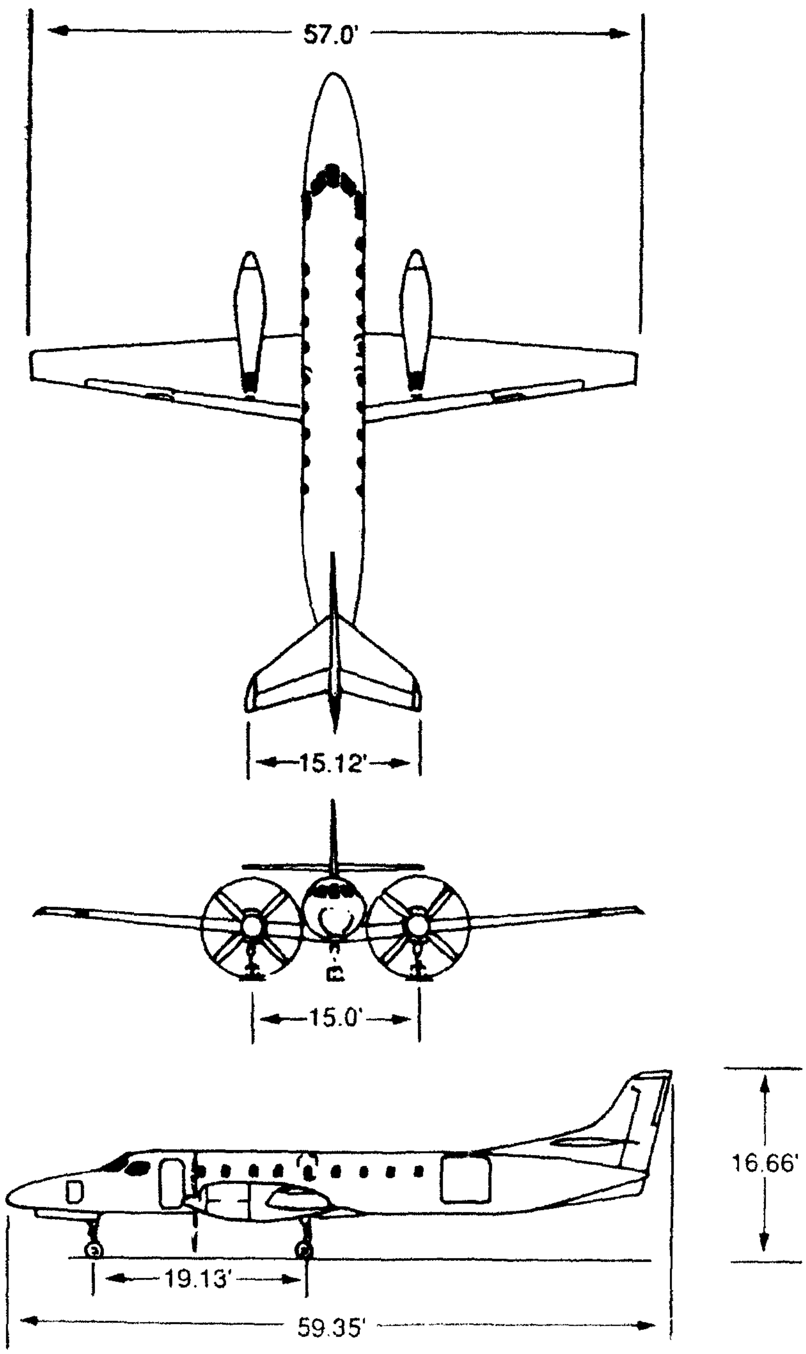


FIGURE 2. METRO III SPECIFICATIONS

TABLE 1. WEIGHT AND BALLAST

ITEM	EST. WEIGHT	C.G. F.S	WGT x F.S
FUSELAGE	3013.00	256.54	772955.02
CREW	400.00	111.00	44400.00
ROW 1 (1)	179.00	148.00	26492.00
ROW 2 (2)	358.00	177.00	63366.00
ROW 3 (2)	358.00	206.00	73748.00
ROW 4 (1)	208.00	235.00	48880.00
ROW 5 (1)	221.00	266.00	58786.00
ROW 6 (1)	186.00	297.00	55242.00
ROW 7 (2)	368.00	328.00	120704.00
ROW 8 (2)	358.00	359.00	128522.00
ROW 9 (2)	358.00	389.00	139262.00
ROW 10 (0)	0.00	419.00	0.00
TOTAL	6007.00		1532357.02
	C.G. FOR ABOVE	255.10	
WING BOX	100.00	244.00	24400.00
FRD CAMERA	22.00	110.00	2420.00
AFT CAMERA	31.50	457.00	14395.50
FWD BAGGAGE	695.00	40.00	27800.00
AFT BAGGAGE	653.00	483.00	315399.00
EXTRA BALLAST	22.00	100.00	2200.00
FUSELAGE	6007.00	255.10	1532357.02
TOTAL	7530.50		1918971.52
	C.G. (BALLASTED	254.95	
	EST. DROP WGT =	7530.50	

The Metro III airframe was modified as follows:

1. Wings and engines were removed.

2. Interior cabin lining was removed so that instrumentation and sensors could be installed.

3. Six-hundred and fifty-three (653) pounds were added to the aft section to simulate baggage.

4. Six-hundred and ninety-five (695) pounds were placed in the forward baggage compartment to simulate maximum cargo.

5. The vertical and horizontal stabilizers were removed.

Table 1 contains the theoretical weight and balance of the airframe use for the test.

The airplane cabin interior was configured for 16 passengers (figure 3) as follows:

A 170-pound anthropomorphic dummy was placed in both the pilot and the copilot seats, at body station 111.

A 165-pound dummy was placed in a standard Metro seat at body station 148.

Two 165-pound dummies, each seated in a standard Metro seat located at body station 177.

Two 16- pound dummies were seated in standard Metro seats at body station 206.

Body station 235 contained a 170-pound anthropomorphic dummy, seated in a stroking seat designed by the FAA's Civil Aeromedical Institute (CAMI), and placed in the center aisle of the aircraft.

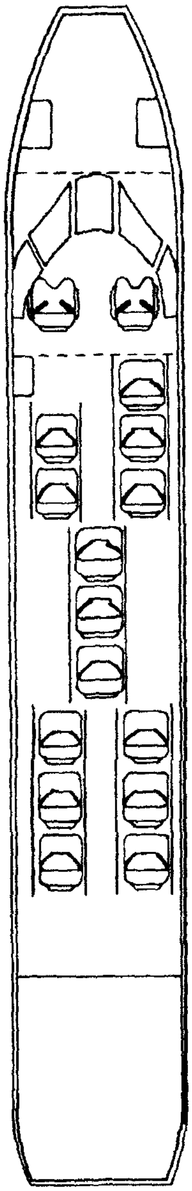
A 170-pound anthropomorphic dummy was seated in a Beechcraft seat at body station 266. This seat was also located in the center aisle.

A standard center aisle Metro seat was placed at body station 297. Seated in this seat was a standard 165-pound dummy.

At body station 328 there was a stroking Metro seat on the left side as well as a standard Metro seat on the right side. Both seats were occupied by 170-pound anthropomorphic dummies.

Two standard metro seats occupied by standard 165-pound dummies were placed at body station 359.

The final row of occupants, at body station 389, contained two standard Metro seats each with a 165-pound dummy. The seat on the right side was positioned facing the rear of the aircraft.



B.S. 111:	Seats	1,2
B.S. 148:	Seat	3
B.S. 177:	Seats	4,5
B.S. 206:	Seats	6,7
B.S. 235:	Seat	8
B.S. 266:	Seat	9
B.S. 297:	Seat	10
B.S. 328:	Seats	11,12
B.S. 359:	Seats	13,14
B.S. 389:	Seats	15,16

HYBRID II ANTHROPOMORPHIC DUMMY (170lbs, Fiftieth Percentile)
Seats 1,2,8,9,11,12

ARMSTRONG MEDICAL "Rescue Randy" (165lbs)
Seats 3,4,5,6,7,10,13,14,15,16

FIGURE 3. METRO III SEAT CONFIGURATION

INSTRUMENTATION

The interior fabric material (side walls and floor) of the Metro III were removed to facilitate installation of instrumentation sensors. The instrumentation was primarily placed on the sidewall frames and floor of the airframe and in the anthropomorphic dummies. The Metro III instrumentation included 22 accelerometers mounted on the aircraft structure as well as 11 accelerometers and 4 load cells mounted in anthropomorphic dummies. Four string potentiometers mounted from the airframe ceiling to the floor were also installed to measure floor deflection. The string potentiometers are capable of measuring deflection distance in either the positive or negative direction, i.e. either expansion or crush. In other words, when the string is pulled out of the potentiometer,it gives a positive reading and when it is extracted back into the potentiometer, it gives a negative reading.

Table 2 lists the channel number, location, and type of sensor used in the test. Figure 4 provides the location as well as the readings for some of the sensors.

The instrumentation complied with SAE J211 instrumentation for impact tests.

The data channels were prefiltered with a SAE J211 channel class 1,000 Hz filter.

The sampling rate was 5,000 samples per second per channel.

The wooden platform rested on 12 load cells. For the Metro III test, three groups of 4 load cells each were connected to three electrical summation boxes. The outputs of the boxes was routed to a sum/amplifier which provide one output to record the total forces on the platform. A vertical accelerometer was also placed on the platform.

A speed trap was also mounted on the platform. The speed trap consisted of two photo detectors at one side with a light source at the other side of the platform. As the aircraft passed through the light, the light beam relays were set to determine time.

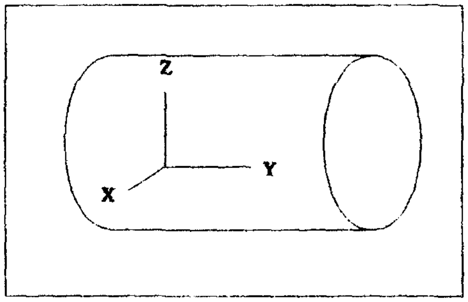
Table 3 gives a summary of the number, location, and type of sensors used for this test.

TABLE 2. INSTRUMENTATION

CHANNEL #	INSTRUMENTATION	LOCATIONS (X,Y,Z Dimensions in inches: Reference Axis System Below)
101	Pilot Side Wall Accel.	-31,121,26
102	Pilot Side Floor Accel.	-12,121,0
103	Co-Pilot Side Wall Accel.	+31,121,26
104	Co-Pilot Side Floor Accel.	+12,121,0
105	Co-Pilot Dummy Accel. #1	+14.5,121,13
106	Co-Pilot Dummy Accel. #2	+14.5,121,13
107	Left Side Wall Accel.	-32,174,29.5
108	Left Side Outboard Seat Track Accel.	-26,174,6
109	Left Side Inboard Seat Track Accel.	-8,174,0
110	Right Side Wall Accel.	+32,174,29
111	Right Side Outboard Seat Track Accel.	+26,174,6
112	Right Side Inboard Seat Track Accel.	+8,174,0
113	Floor String Pot #1	-3,217,-6
114	Floor String Pot #2	+3,217,-6
115	Left Side Inboard Seat Track String Pot	-8,217,0
201	Pilot Dummy Load Cell	-12,121,13
202	Pilot Dummy Accel. #1	-12,121,13
203	Pilot Dummy Accel. #2	-12,121,13
204	CAMI Seat Dummy Load Cell	+0,235,14
205	CAMI Seat Dummy Accel. #1	+0,235,14
206	CAMI Seat Dummy Accel. #2	+0,235,14
207	Beechcraft Seat Load Cell	+0,266,14
208	Standard Metro Seat Dummy Load Cel	+17,297,13
209	Standard Metro Seat Dummy Accel.	+17,297,13
210	Left Side Wall Accel.	-32,422,28
211	Left Side Outboard Seat Track Accel.	-26,422,6
212	Left Side Inboard Seat Track Accel.	-8,422,0
213	Right Side Wall Accel.	+32,317,30
214	Right Side Outboard Seat Track Accel.	+26,317,6
215	Right Side Inboard Seat Track Accel.	+8,317,0

TABLE 2. INSTRUMENTATION (Continued)

216	Left Side Wall Accel.	-32,317,30
217	Left Side Outboard Seat Track Accel.	-26,317,6
218	Left Side Inboard Seat Track Accel.	-8,317,0
219	Right Side Wall Accel.	+32,422,28.5
220	Right Side Outboard Seat Track Accel.	+26,422,6
221	Right Side Inboard Seat Track Accel.	+8,422,0
222	Right Side Inboard Seat Track String Pot	+8,217,0
223	Beechcraft Seat Dummy Accel. #1	+0,235,14
224	Beechcraft Seat Dummy Accel. #2	+0,235,14
225	Stroking Metro Seat Dummy Load Cell	-17,328,13
226	Stroking Metro Seat Dummy Accel. #1	-17,328,13
227	Stroking Metro Seat Dummy Accel. #2	-17,328,13
228	Aircraft Drop Velocity	
229	Platform Accel.	
230	Spare	
231	Platform Load Cell	



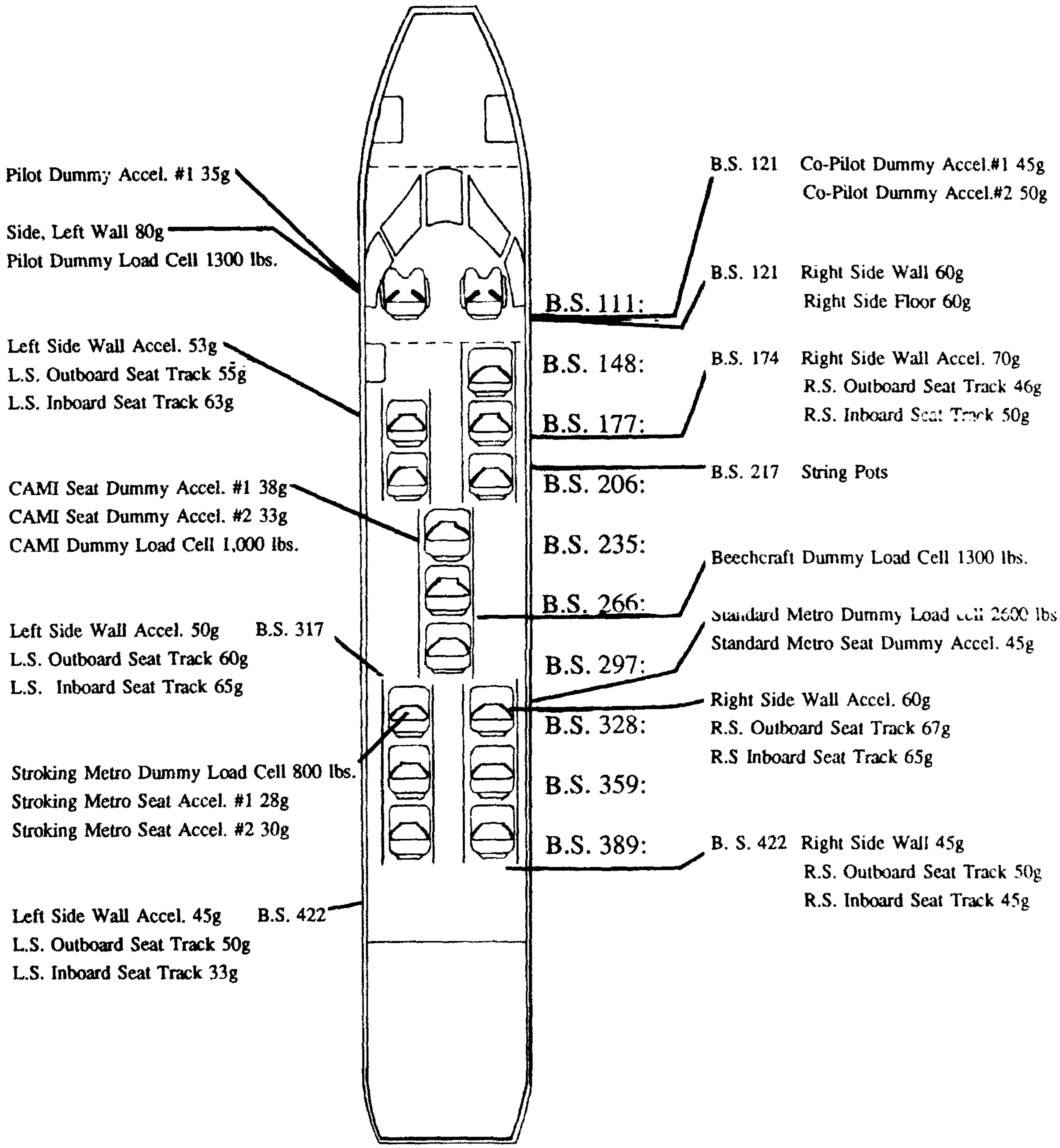


FIGURE 4. METRO III TEST RESULTS

TABLE 3. INSTRUMENTATION LIST

	String Pot.	Accelerometers Vert.	Lat.	Long.	Load Cell	Number of Channels
Fuselage	4	8	-	-	-	12
Floor	-	14	-	-	-	14
Platform	-	1	-	-	1	2
Dummy (pelvis)	-	11	-	-	5	16
TOTAL	4	34	-	-	6	44

Each of these sensors were hardwired into a Neff 490 Data Acquisitions System. A trigger signal, at the time the power was applied to hook release, was used to initiate data acquisition.

DATA ACQUISITION SYSTEM

The data acquisition system consists of a 46 channel Neff System, operated by an AT&T 386 workstation. A data analysis program called DaDisp was used for the post-test analysis.

NEFF DATA ACAUISITION SYSTEM.

The Neff System 490 is a data acquisition system sampling all channels at 5000 samples per second per channel. All data for each channel are stored on inboard memory (256K bytes) during the test.

Each channel has a differential input amplifier with full- scale inputs from 5 millivolts to 10 volts dc and a cutoff frequency of 1,000 hertz. The analog to digital converter is a 12-bit converter with an accuracy of 0.1 percent of programmable full-scale inputs. The system supplies all necessary excitation voltages for string potentiometers and accelerometers and load cells. Before each test, the system was used to balance all inputs to compensate for any variation in the zero state of the instruments.

For further test analysis these data are transferred to an IBM compatible machine by an IEEE 488 Interface.

AT&T 386 WORKSTATION.

The computer system is a 386-based personal computer running at 25 megahertz. This system, with the assistance of software, was used to set up each individual channel before the test and to analyze the data after the test.

DaDISP SOFTWARE.

This software allows the user to put data in a worksheet format, which is used to analyze, filter, integrate, and graph the data.

PHOTOGRAPHIC DOCUMENTATION.

High speed (500 fps) color and real-time video coverage were used during the dr p test. Three 16mm, color, high-speed (500 fps) cameras viewed the outside of the aircraft (figure 5). Two similar cameras were placed inside the aircraft; one was hung from the cockpit ceiling facing aft, and one was in the rear seat area facing forward. The high-speed film coverage was time-synchronized with the data acquisition system so that the data traces can be directly correlated with the high-speed film. In addition, 35mm color still photos were taken (figures 6 through 65).

Numerous pre-test and post-test photographs were taken; however, only a limited number are included in this report. A brief description of these photographs follows (refer to figure 3 for seat number locations):

Figure 6 shows the test article on the platform prior to the test.

Figure 7 shows the pilot and copilot seats prior to the test.

Figure 8 is a interior view of the fuselage, forward to aft, prior to the test.

Figure 9 is also the interior prior to the test, viewing aft to forward.

Figure 10 shows the release of the specimen from 11.2 feet.

Figure 11 shows the impact of the specimen with the platform.

Figure 12 and 13 are two forward-to-aft views of the aircraft interior after the drop.

Figures 14-16 show the post-test aircraft interior viewing aft to forward.

Figure 17 is a view of the pilot and copilot seats after the test.

Figure 18 and 19 are individual pictures of the pilot and copilot seats, respectively, after the test.

Figure 20 is a post-test view of seat 3. Figure 21 shows the damage to the inboard aft leg of seat 3, while figure 22 is a view of the seat track under seat 3.

Figures 23 and 24 show an overall view and the inboard aft leg of seat number 4 after the test, while figure 25 shows the seat track.

Figure 26 is a post-test view of seat 5. Figures 27 and 28 show the inboard and outboard aft legs respectively, and figure 29 shows the damage to the seat track.

Figure 30 is a view of seat 6 after the test. Figure 31 shows the damage to the inboard aft leg, while figure 32 is a view of the seat track.

Figure 33 shows seat 6 (on the left) and seat 7. Figure 34 shows the damage to the inboard aft leg of seat 7, and figure 35 shows the damage to the seat track under seat 7.

Figure 36 is the rear view of the CAMI seat (seat 8) after the test. Figure 37 shows a closeup of the seat pan after the test; notice the deflection of the energy absorbing mechanism caused by the impact.

Figure 38 is a post-test view of the Beechcraft seat (seat 9), which had no visible damage.

Figure 39 shows the center aisle Metro seat (seat 10) after the test. Figure 40 is a post-test view of seat 11, the stroking Metro seat; and figure 41 is a view of the broken seat back attachment on seat 11. Figure 42 shows the seat track under seat 11.

Figure 43 shows seat 12 after the test. Figure 44 shows the resulting damage on the inboard aft leg of seat 12.

Figure 45 illustrates the damage incurred on seat 13 during the test. Figure 46 is a close-up of the inboard aft leg showing damage resulting from the impact.

Figure 47 is a post-test rear view of seat 14, while figure 48 is a closeup of the track under seat 14.

The damage to seat 15 can be seen from a variety of angles in figures 49, 50 and 51

The seat track is visible in figure 52.

Figure 53 shows the final seat (16), which is rear facing, after the test. Figure 54 is a view of the inboard legs of seat 16, while figure 55 shows the seat track.

Figures 56, 57 and 58 show the damage to the underside of the aircraft caused by the drop test.

Figures 59, 60 and 61 view the inside of the forward baggage compartment after the test.

The interior of the fuselage also experienced some damage during the test. Figure 62 shows an example of such damage, occurring at body station 159. Figure 63 shows more structural damage at body station 189. Ceiling damage can be seen in figure 64, while sidewall damage is observed in figure 65.

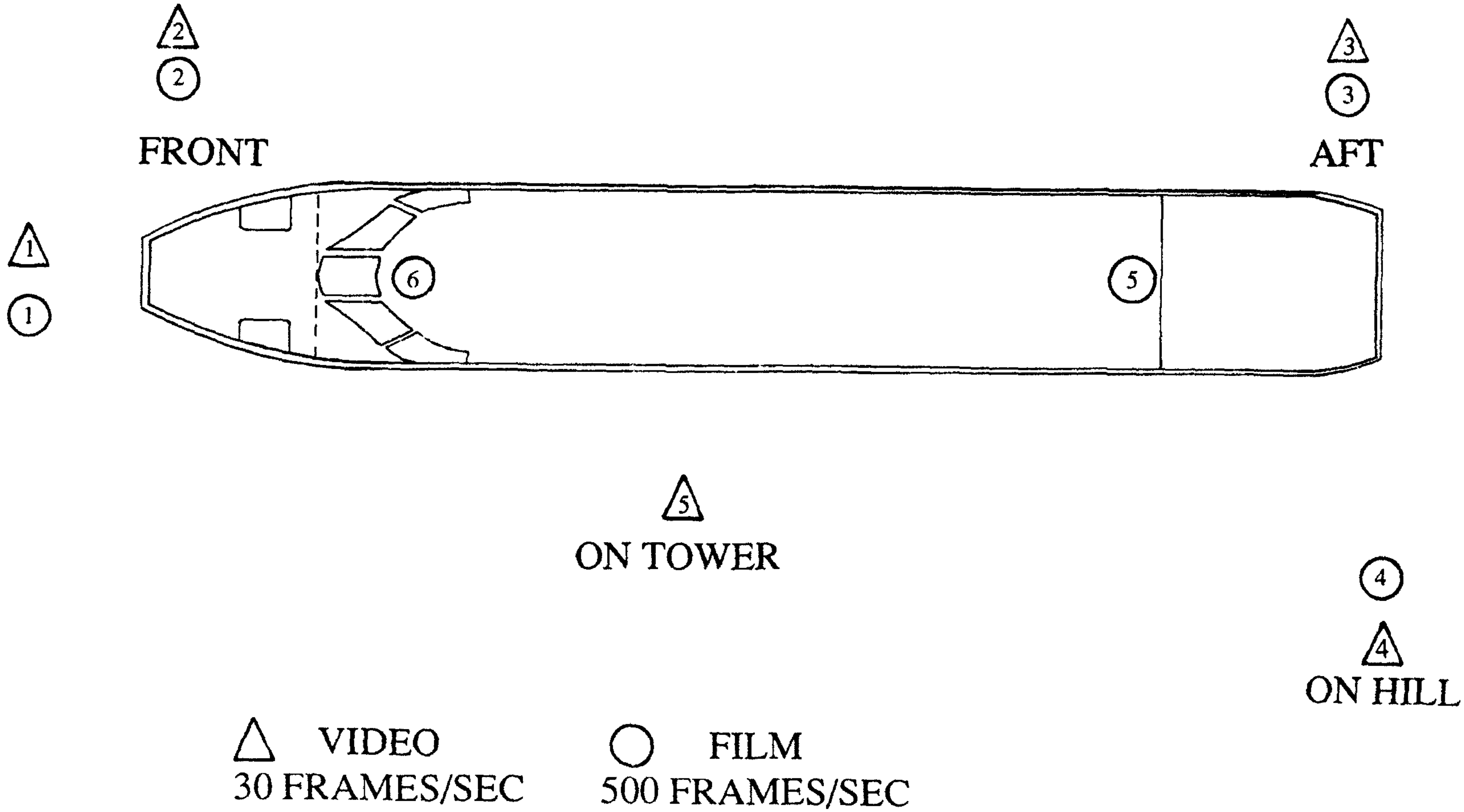


FIGURE 5. METRO III CAMERA LOCATIONS

FIGURE 6. TEST ARTICLE

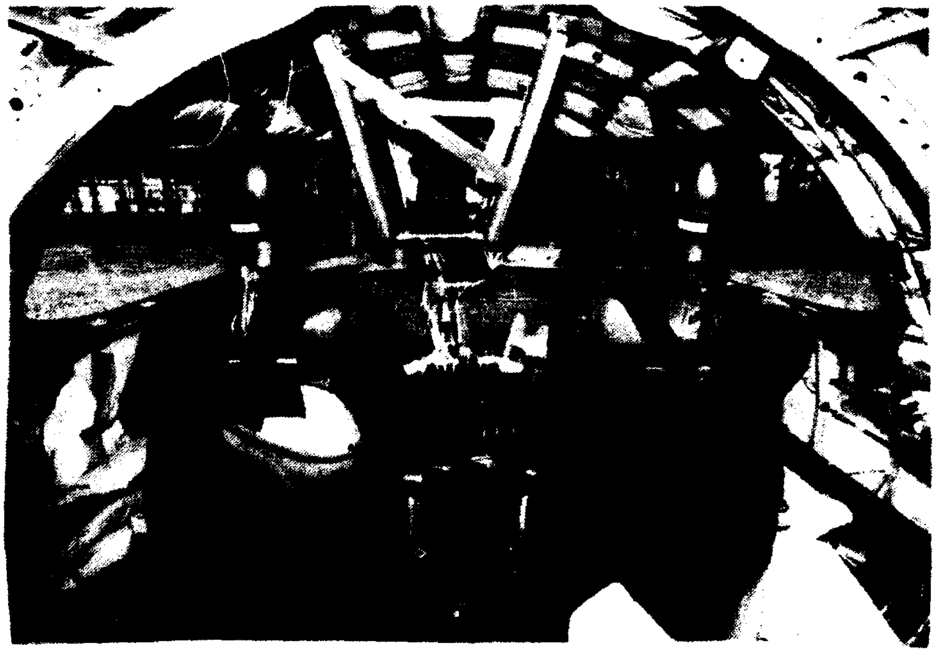


FIGURE 7. PRE TEST PILOT AND COPILOT SEATS

FIGURE 8. PRE TEST FUSELAGE INTERIOR, FORWARD TO AFT

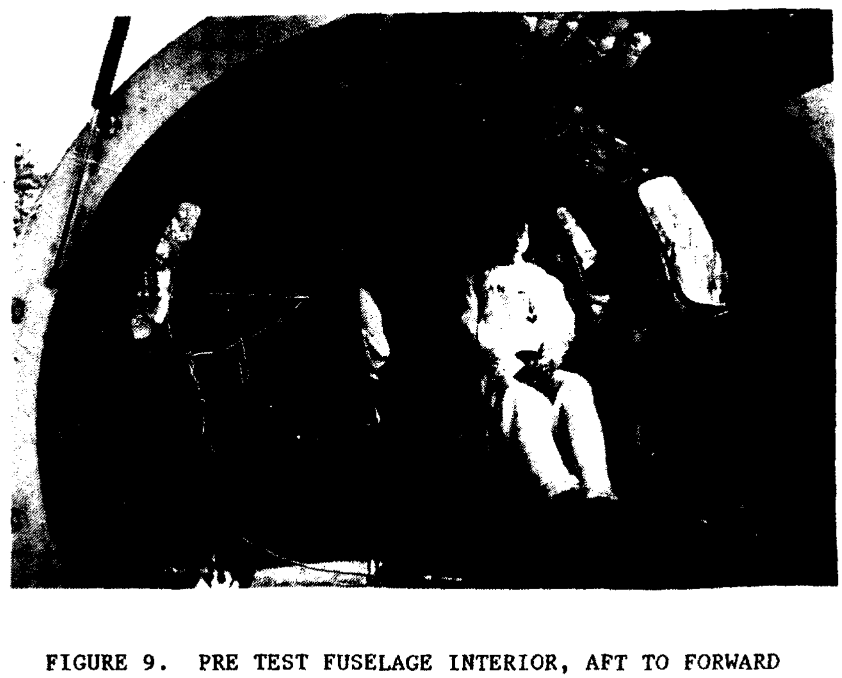


FIGURE 9. PRE TEST FUSELAGE INTERIOR, AFT TO FORWARD

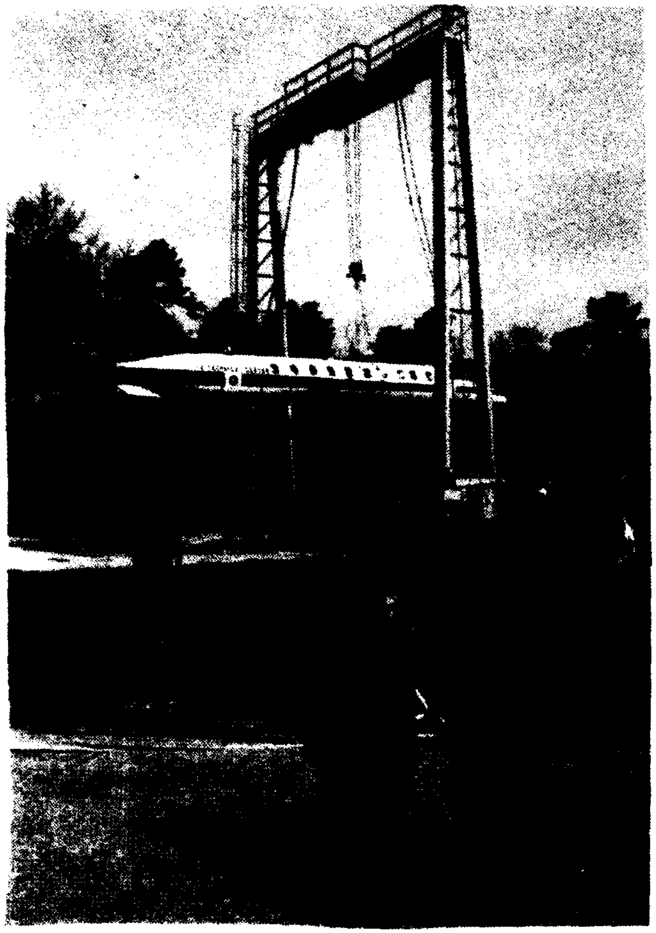


FIGURE 10. TEST ARTICLE RELEASE

FIGURE 11. TEST ARTICLE IMPACT

FIGURE 12. POST TEST FUSELAGE INTERIOR, FORWARD TO AFT - 1

FIGURE 13. POST TEST FUSELAGE INTERIOR, FORWARD TO AFT - 2

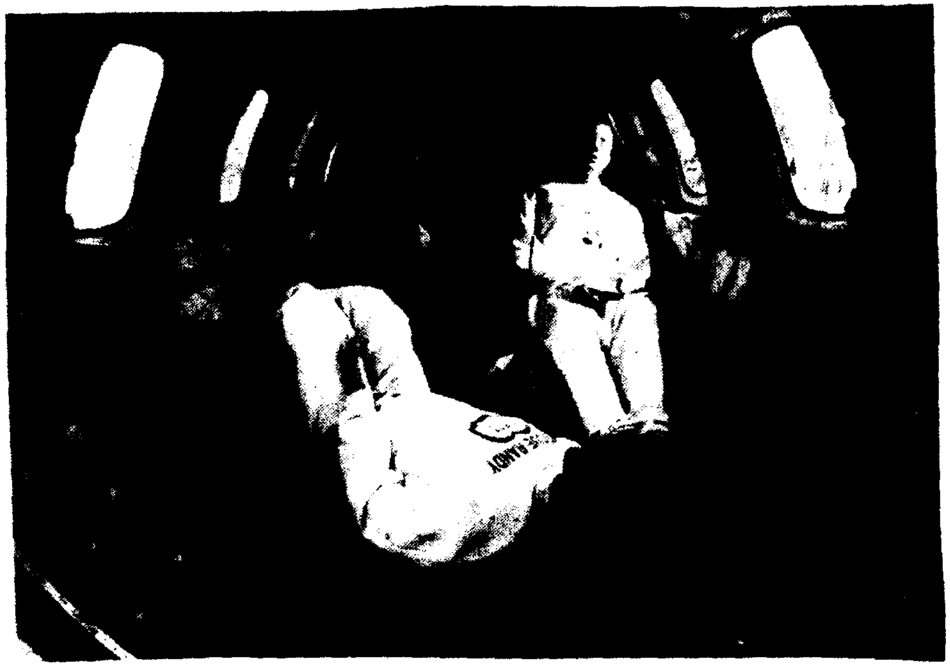


FIGURE 14. POST TEST FUSELAGE INTERIOR, AFT TO FORWARD - 1

FIGURE 15. POST TEST FUSELAGE INTERIOR, AFT TO FORWARD - 2

FIGURE 16. POST TEST FUSELAGE INTERIOR, AFT TO FORWARD - 3

FIGURE 17. POST TEST PILOT AND COPILOT SEATS

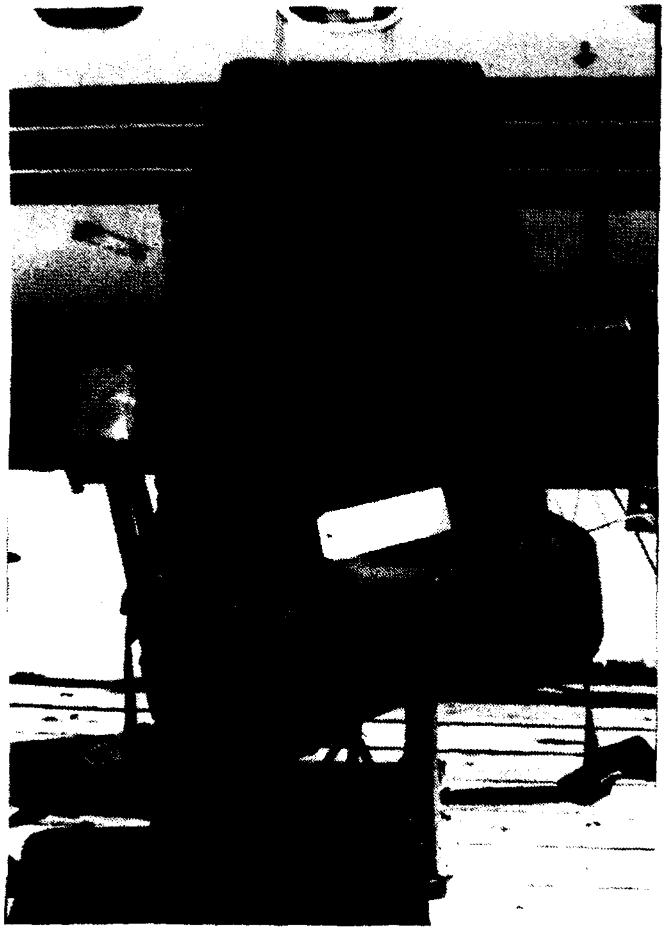


FIGURE 18. POST TEST PILOT SEAT

FIGURE 19. POST TEST COPILOT SEAT

FIGURE 20. POST TEST SEAT 3

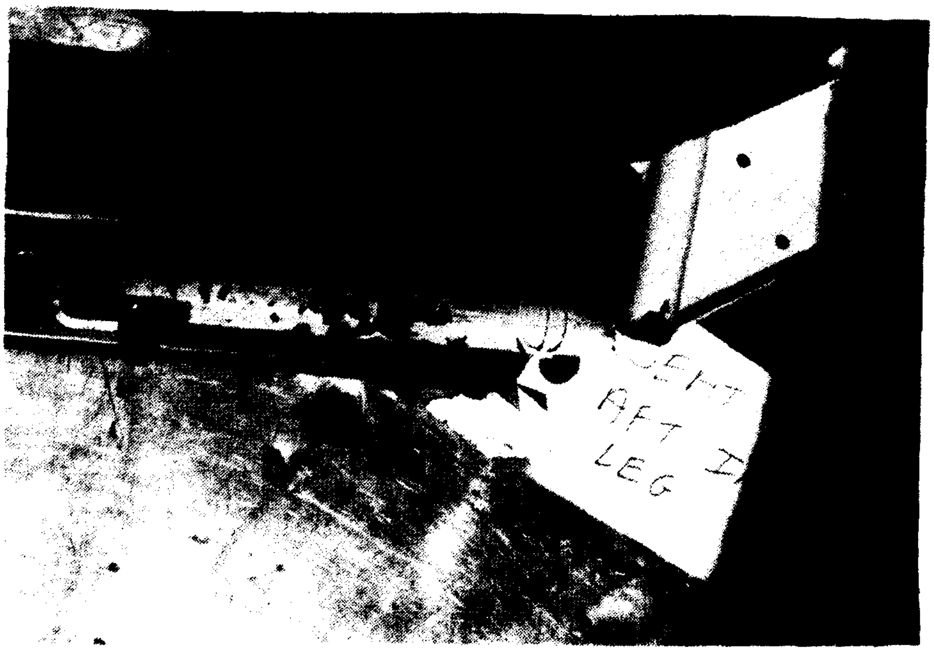


FIGURE 21. POST TEST SEAT 3, INBOARD AFT LEG

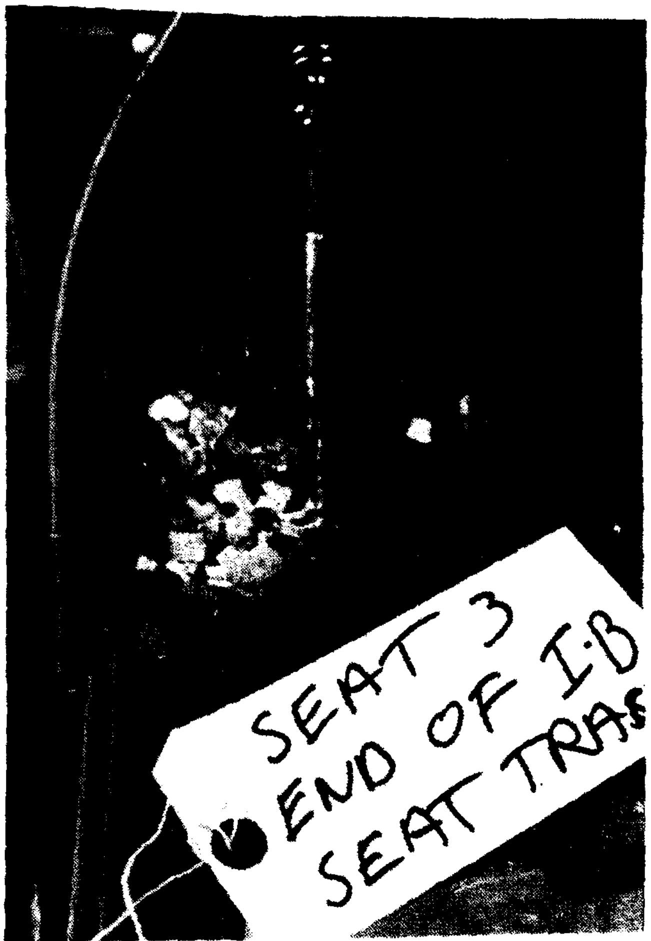


FIGURE 22. POST TEST SEAT TRACK, SEAT 3

FIGURE 23. POST TEST SEAT 4

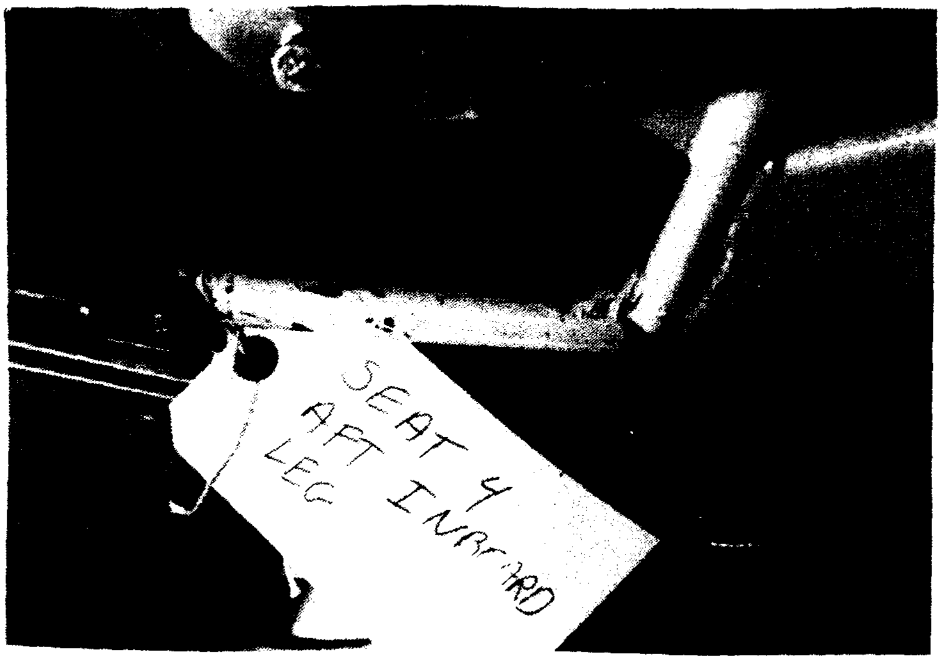


FIGURE 24. POST TEST SEAT 4, INBOARD AFT LEG

FIGURE 25. POST TEST SEAT TRACK, SEAT 4

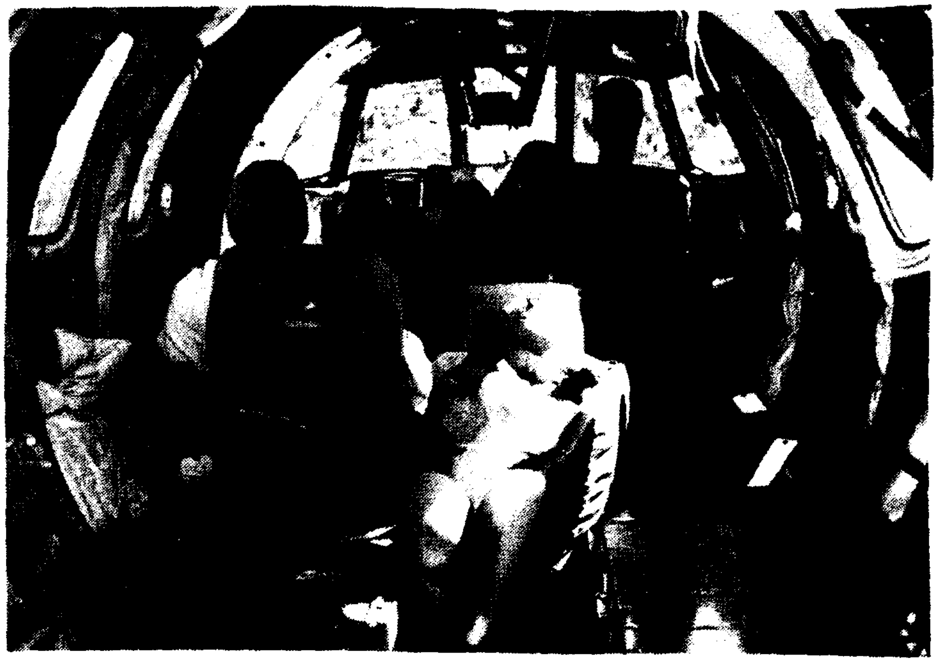


FIGURE 26. POST TEST SEAT 5

FIGURE 27. POST TEST SEAT 5, INBOARD AFT LEG

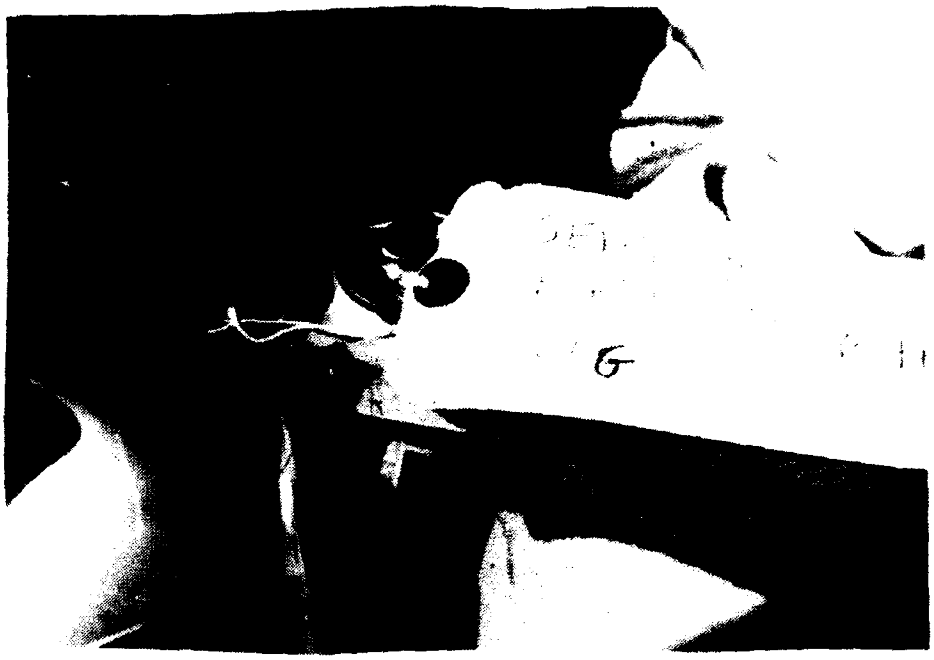


FIGURE 28. POST TEST SEAT 5, OUTBOARD AFT LEG

FIGURE 29. POST TEST SEAT TRACK, SEAT 5

FIGURE 30. POST TEST 6

FIGURE 31. POST TEST SEAT 6, INBOARD AFT LEG

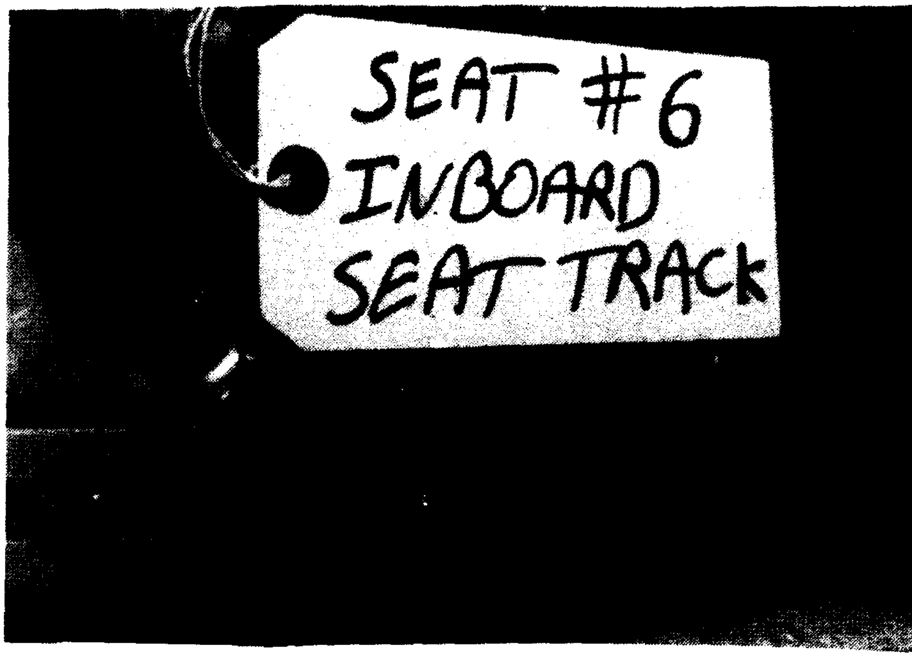


FIGURE 32. POST TEST SEAT TRACK, SEAT 6

FIGURE 33. POST TEST SEAT 6 AND SEAT 7

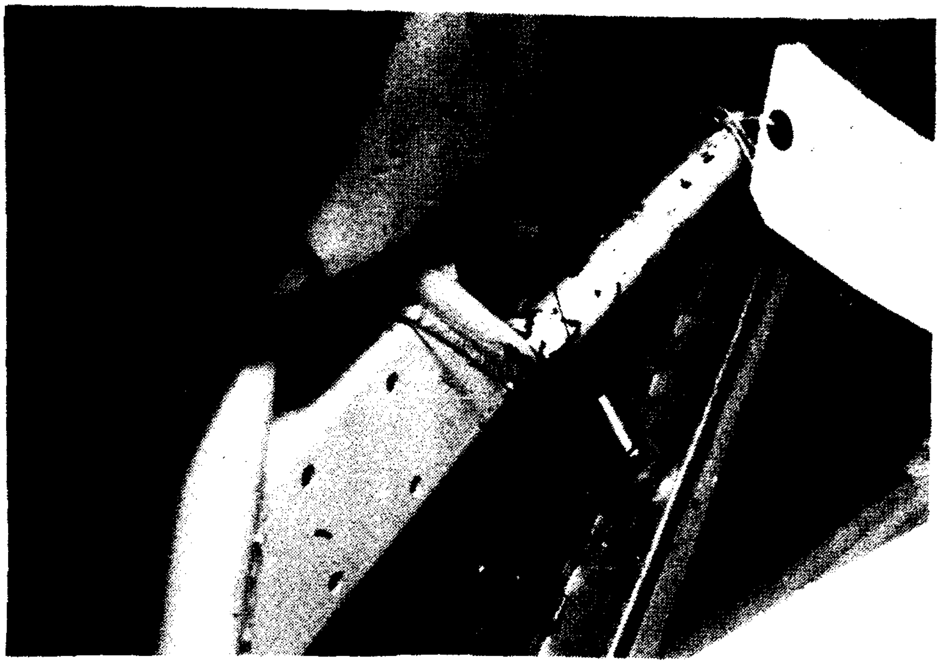


FIGURE 34. POST TEST SEAT 7, INBOARD AFT LEG

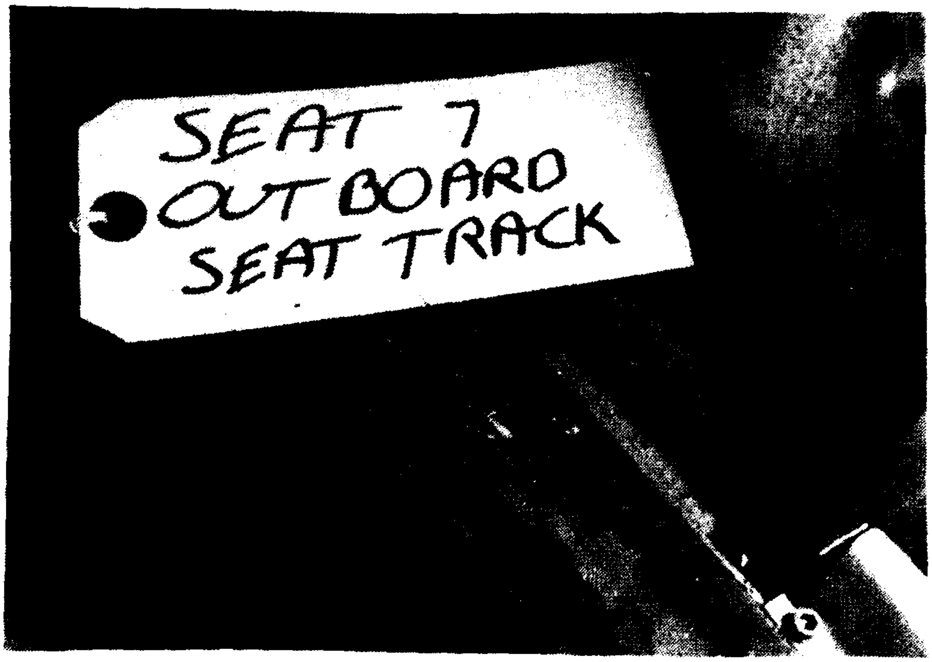


FIGURE 35. POST TEST SEAT TRACK, SAEAT 7

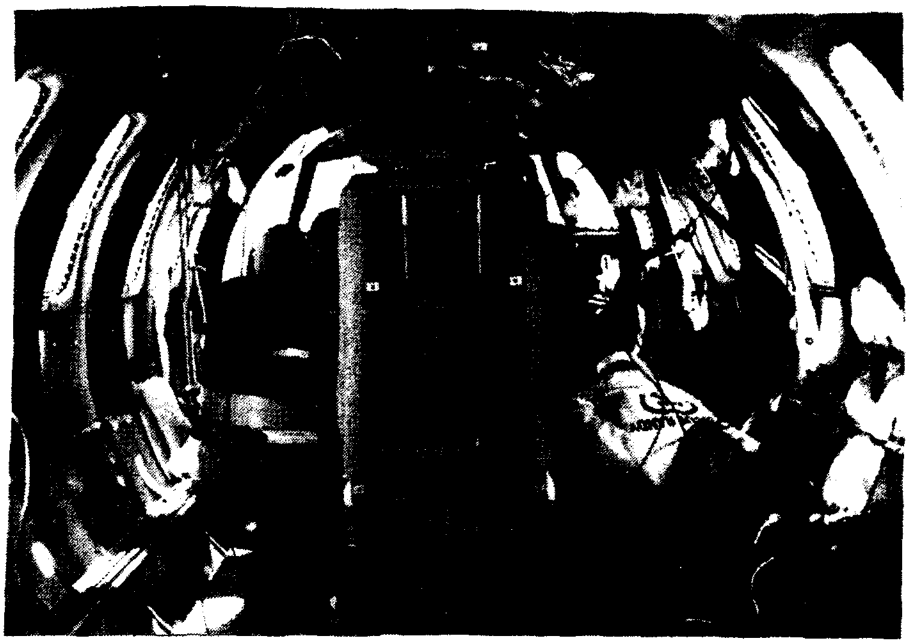


FIGURE 36. POST TEST SEAT 8, CAMI SEAT

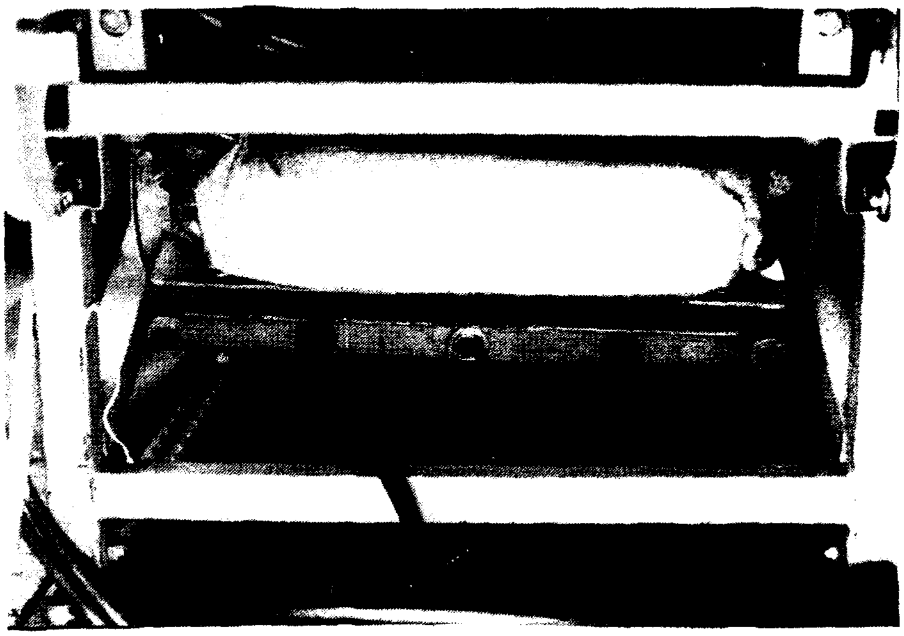


FIGURE 37. POST TEST CAMI SEAT PAN

FIGURE 38. POST TEST SEAT 9, BEECHCRAFT SEAT

FIGURE 39. POST TEST SEAT 10, CENTER AISLE METRO SEAT

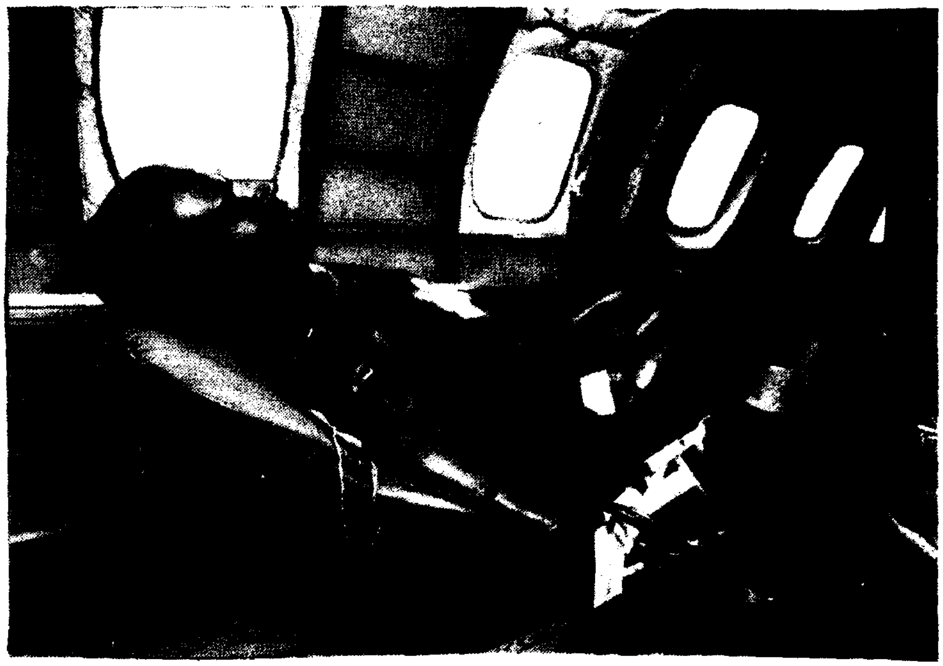


FIGURE 40. POST TEST SEAT 11, STROKING METRO SEAT

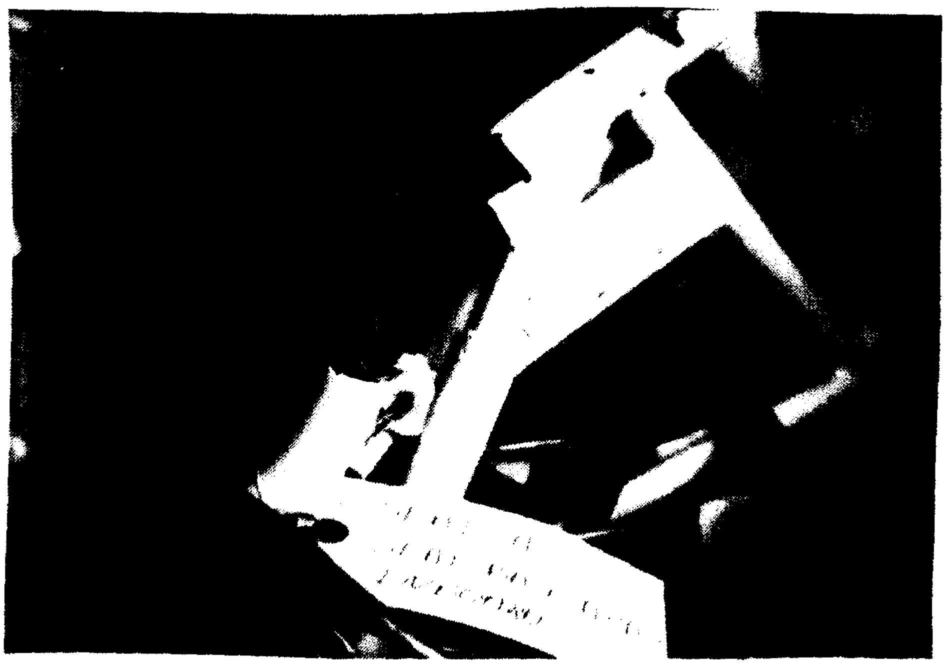


FIGURE 41. POST TEST SEAT 11, BROKEN SEAT BACK ATTACHMENT

FIGURE 42. POST TEST SEAT TRACK, SEAT 11

FIGURE 43. POST TEST SEAT 12

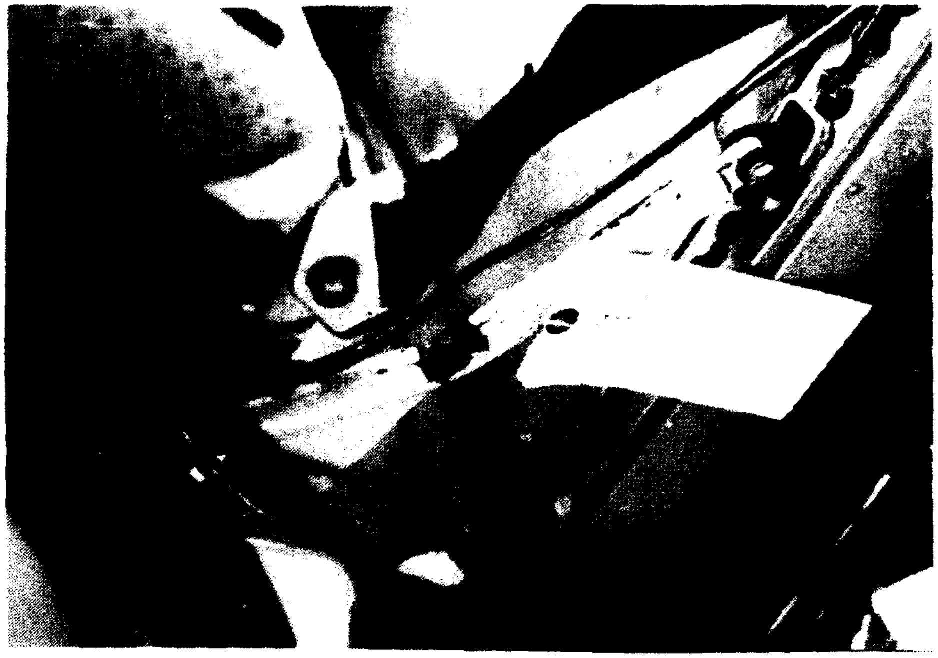


FIGURE 44. POST TEST SEAT 12, INBOARD AFT LEG

FIGURE 45. POST TEST SEAT 13

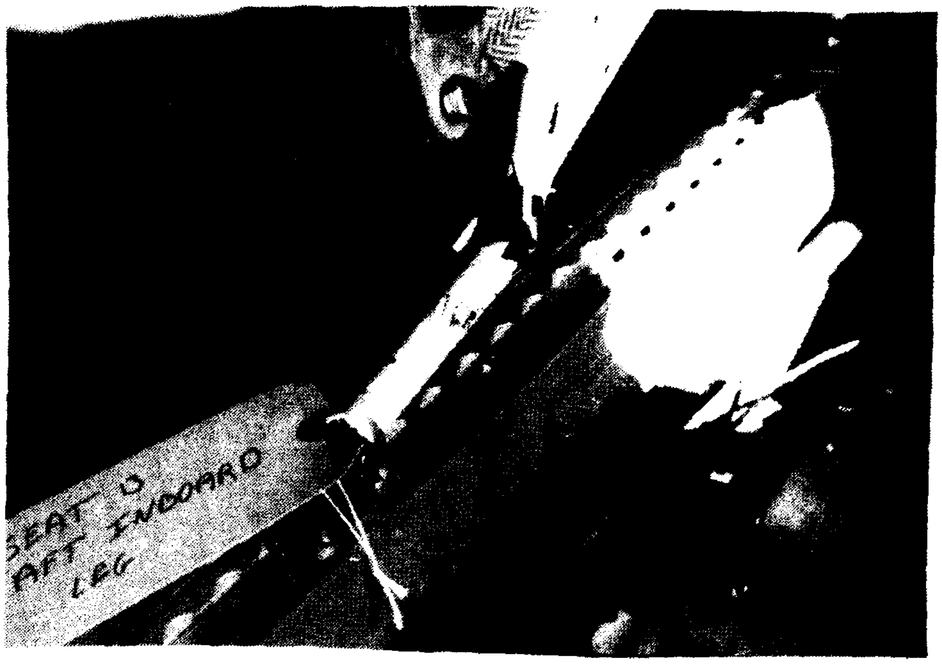


FIGURE 46. POST TEST SEAT 13, INBOARD AFT LEG

FIGURE 47. POST TEST SEAT 14

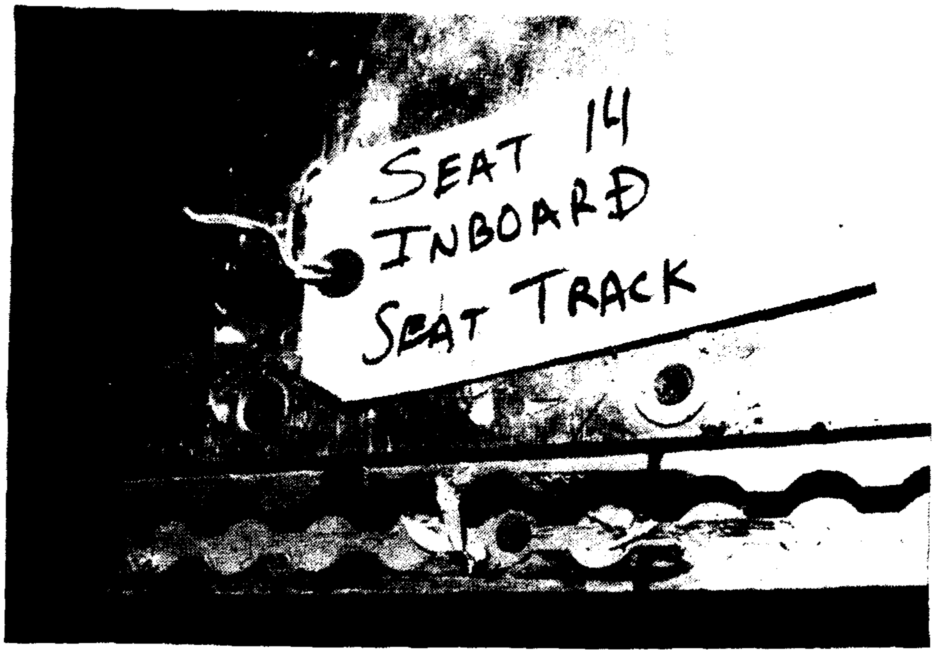


FIGURE 48. POST TEST SEAT TRACK, SEAT 14

FIGURE 49. POST TEST SEAT 15 - 1

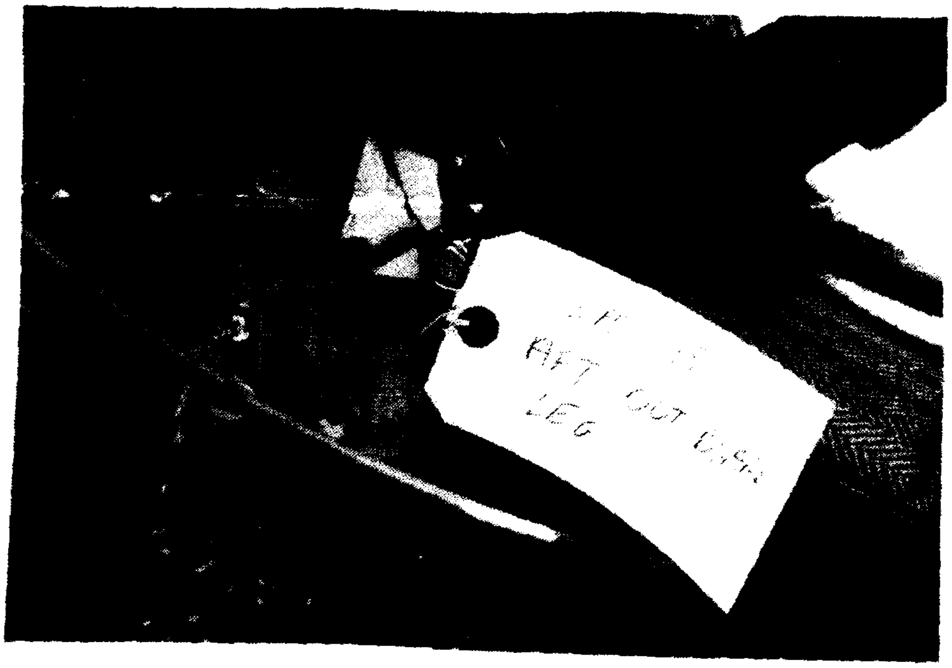


FIGURE 50. POST TEST SEAT 15 - 2

FIGURE 51. POST TEST SEAT 15 - 3

FIGURE 52. POST TEST SEAT TRACK, SEAT 15

FIGURE 53. POST TEST SEAT 16

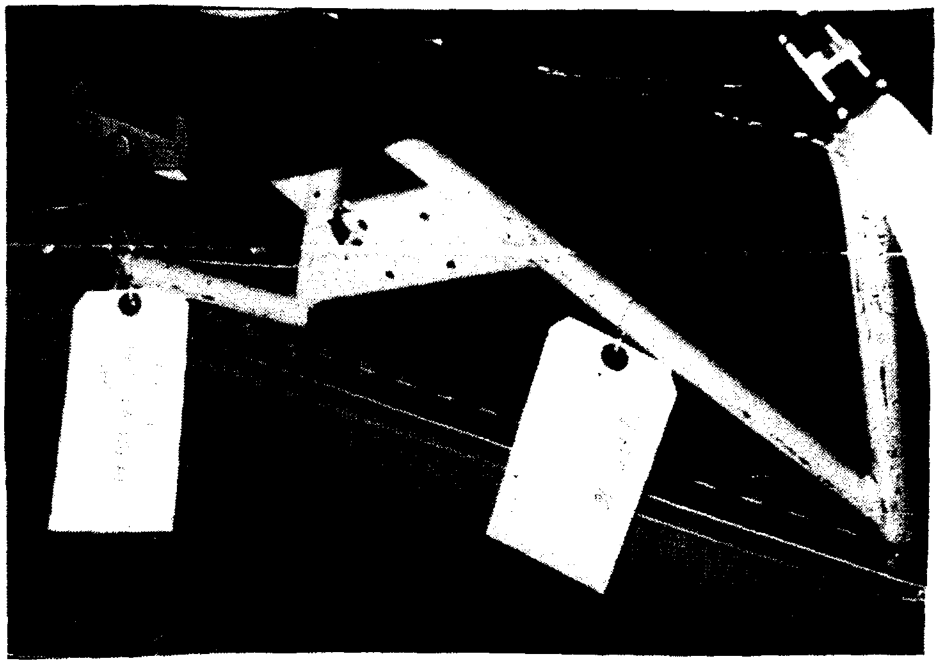


FIGURE 54. POST TEST SEAT 16, INBOARD LEGS

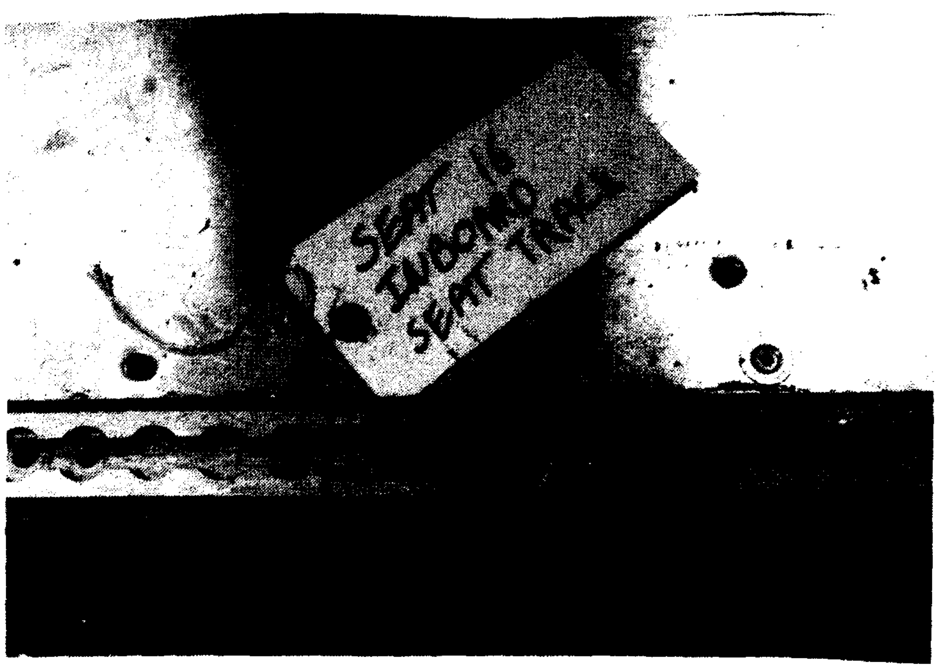


FIGURE 55. POST TEST SEAT TRACK, SEAT TRACK

FIGURE 56. POST TEST UNDERSIDE FUSELAGE DAMAGE - 1

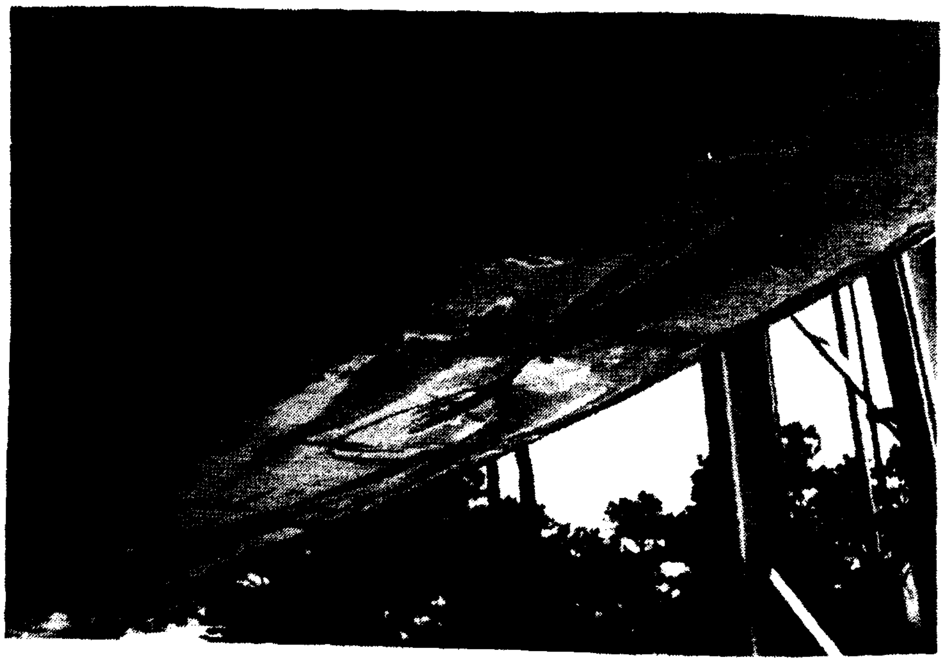


FIGURE 57. POST TEST UNDERSIDE FUSELAGE DAMAGE - 2

FIGURE 58. POST TEST UNDERSIDE FUSELAGE DAMAGE - 3

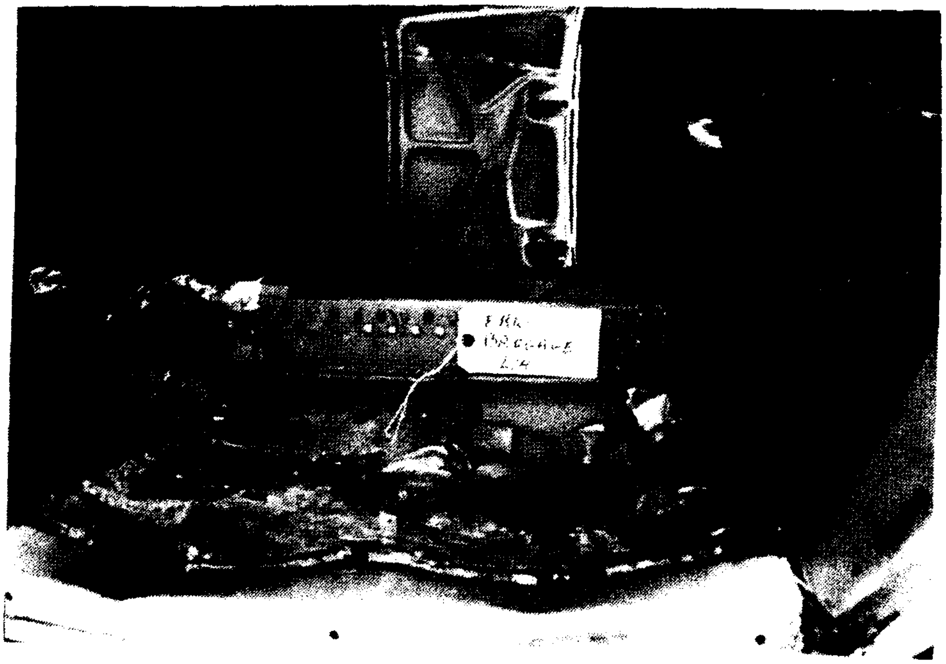


FIGURE 59. POST FORWARD BAGGAGE COMPARTMENT - 1

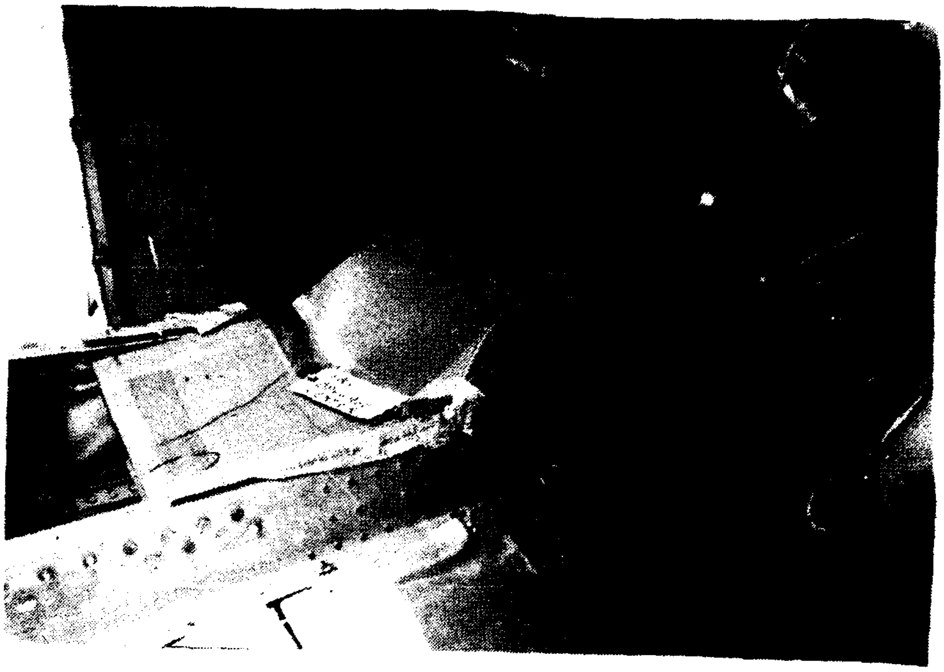


FIGURE 60. POST FORWARD BAGGAGE COMPARTMENT - 2

FIGURE 61. POST FORWARD BAGGAGE COMPARTMENT - 3

FIGURE 62. POST TEST INTERIOR FUSELAGE, BODY STATION 159

FIGURE 63. POST TEST INTERIOR FUSELAGE, BODY STATION 189

FIGURE 64. POST TEST INTERIOR FUSELAGE, CEILING

FIGURE 65. POST TEST INTERIOR FUSELAGE, WALL

POST-TEST ANALYSIS PROCEDURE

The test article impact was identified to be approximately 0.9 seconds after hook release. The unfiltered digital data were filtered with SAE J211 Class 60 filter for acceleration, displacement, and platform load cell data channels. A Class 600 filter was used on the dummy lumbar column load cell data channels. In addition, velocity plots were made by integrating the acceleration data, and filtering the results with a class 180 filter. Filtered acceleration graphs can be seen in appendix A. The data were read into files which include at least 150 milliseconds of data from the point of impact.

RESULTS

1. Structural damage to the Metro III airframe was minimal. Deformation of the fuselage at the wing box was less than 2 inches.

2. The peak floor accelerations at the seat tracks averaged 57g's for this airplane configuration.

3. The Beechcraft seat utilized in this test incorporated a double cushion and flexible seat pan. The maximum pelvic/lumbar column load measured in the anthropomorphic dummy was 1,200 pounds.

The following is a brief description of the damage sustained by the individual seats aboard the aircraft during the test. The seats have been labeled 1-16 with the pilot seat being number one. Refer to figure 3 for a diagram of the seat arrangement.

SEAT 1 (Pilot Seat) Body Station (B.S.) 111

DAMAGE: The seat frame broke on the inboard side under the seat cushion. A support tube on the inboard side was also broken.
POSITION: The seatback was upright and unmoved. The seat pan was deflected down toward the inboard side.

SEAT 2 (Copilot Seat) B.S. 111

DAMAGE: The seat frame broke on the inboard side under the seat cushion.
POSITION: The seat back was upright and unmoved. The seat pan was deflected down toward the inboard side.

SEAT 3 (Standard Metro Seat) B.S. 148

DAMAGE: The inboard and outboard aft legs were broken off at the top of the legs.
POSITION: The seat was lying on its inboard side across the center isle. The upper part of the aft side of the seat back was against the legs of the dummy in seat 4. The two broken aft legs remained in the seat tracks.

SEAT 4 (Standard Metro Seat) B.S. 177

DAMAGE: The aft inboard leg was cracked and bent to the point where it was almost broken apart. The aft outboard leg was broken off. The damage to both legs occurred just below the seat pan.
POSITION: The seat remained in its original position; however, the front legs slid forward approximately 4 inches and the seat-back was leaning rearward at approximately 45 degrees and resting on the legs of the dummy in seat 6. The broken outboard aft leg remained in the seat track.

SEAT 5 (Standard Metro Seat) B.S. 177
DAMAGE: The inboard and outboard aft legs were broken. These breaks occurred at the top of the legs. The forward inboard leg attachment was sheared off and remained in the seat track.
POSITION: The seat was lying on its inboard side in the center aisle. The dummy's head was pressed against the legs of seat 6. The broken leg pieces remained in the seat track.

SEAT 6 (Standard Metro Seat) B.S. 206
DAMAGE: The inboard and outboard aft legs were cracked and bent almost to the point of separation.
POSITION: The front legs slid forward approximately 4 inches and the seat back was bent at the base and resting against seat 8.

SEAT 7 (Standard Metro Seat) B.S. 206
DAMAGE: The aft inboard leg was cracked and almost separated at the top. The aft outboard leg was broken off at the top. The base of the seat back on the outboard side was broken.
POSITION: The seat back was almost horizontal and twisted down toward the outboard side. The broken seat leg remained in the seat track. The front legs slid forward approximately 4 inches.

SEAT 8 (CAMI Seat) B.S. 235
DAMAGE: No apparent damage.
POSITION: Seat pan deflected downward approximately 4.5 inches.

SEAT 9 (Beechcraft Seat) B.S. 266
DAMAGE: No apparent damage.
POSITION: Original position maintained.

SEAT 10 (Center Aisle Metro Seat) B.S. 297
DAMAGE: The right side aft leg was slightly bent. The seat back was bent at the base and lying horizontal.
POSITION: The seat remained in its original position.

SEAT 11 (Modified Stroking Metro Seat) B.S. 328
DAMAGE: The inboard seat frame was cracked in half. The seat back was leaning rearward approximately 45 degrees. (It should be noted that there was a slight deformation of this seat back prior to this drop test. The seat was reclining slightly due to a prior test at the Civil Aeromedical Institute. The effects the pre-test deformation had on the results of this test are unknown.)
POSITION: The front legs slid forward approximately 4 inches.

SEAT 12 (Standard Metro Seat) B.S. 328
DAMAGE: The upper portion of the inboard and outboard aft legs and seat back were slightly bent.
POSITION: The seat back was bent slightly rearward and the front legs slid forward approximately 3 inches.

SEAT 13 (Standard Metro Seat) B.S. 359

DAMAGE: The outboard aft leg was bent and cracked. The inboard aft leg was severely bent but not cracked. The seat back was bent rearward at its base.

POSITION:

The front legs slid forward approximately 4 inches. The seat back was leaning rearward approximately 45 degrees.

SEAT 14 (Standard Metro Seat) B.S. 359

DAMAGE: The inboard aft leg was cracked but not separated at its top. The outboard leg was bent at the top.

POSITION: The seat was in its original position. The seat back was leaning rearward and resting against the seat back of seat 16.

SEAT 15 (Standard Metro Seat) B.S. 389

DAMAGE: The inboard and outboard aft legs were broken off at the top. The inboard forward leg attachment separated.

POSITION: The seat was lying on its back and angled across the center aisle. The two broken legs remained in the seat track.

SEAT 16 (Standard Metro Seat) B.S. 389

(The seat is a left-side seat which was turned around and placed on the right side causing the passenger to face the rear of the plane)

DAMAGE: Both forward legs (normally aft) were damaged. The inboard leg was completely broken, while the outboard leg was severely bent.

POSITION: The seatback was bent forward slightly. It was also resting against the back of seat 14. The broken leg remained in the seat track.

As a result of the test, the fuselage experienced a slight deformation, varing throughout its length. The deformation was calculated by measuring the distance from a set point on the aircraft to the platform, both prior to and after the test. An offset value was used to compensate for the wingbox prior to the test, and the forward lean of the aircraft about the wingbox, after the test. See table 4 and figure 66. No significant crush of the airframe could be determined by film analysis.

TABLE 4. CRUSH MEASUREMENT (IN INCHES)

	PRE TEST		
F.S.	LEFT	RIGHT	OFFSET
95	27.50	26.88	3.63
189	26.75	26.25	3.63
254	27.13	26.63	3.63
347	26.69	26.13	3.63
438	25.44	25.00	3.63

	POST TEST		
F.S.	LEFT	RIGHT	OFFSET
95	23.63	22.75	0.50
189	24.13	23.50	2.00
254	25.50	24.63	3.00
347	26.00	25.50	4.38
438	25.50	25.13	4.38

	CRUSH (Avg)
F.S.	
95	0.88
189	1.06
254	1.19
347	1.41
438	0.66

The above readings were measured from a set point on the outside of the aircraft to the platform. The offset value is the distance from the bottom outside of the aircraft to the platform. See diagram below.

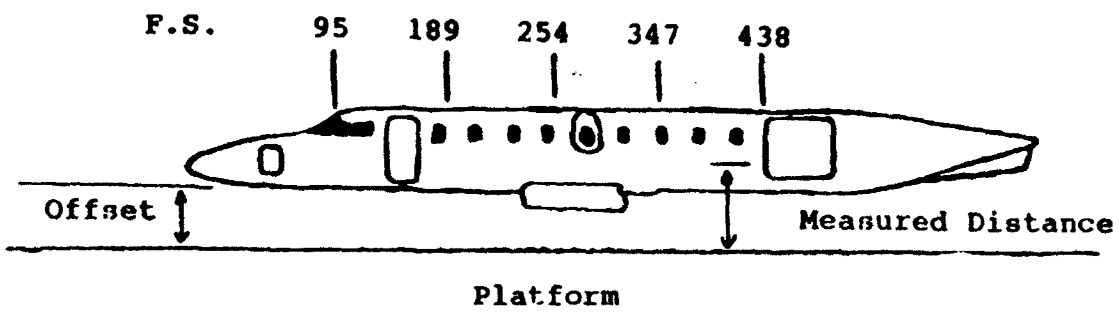


Diagram not drawn to scale

FIGURE 66. FUSELAGE CRUSH MEASUREMENT LOCATIONS

CONCLUSION

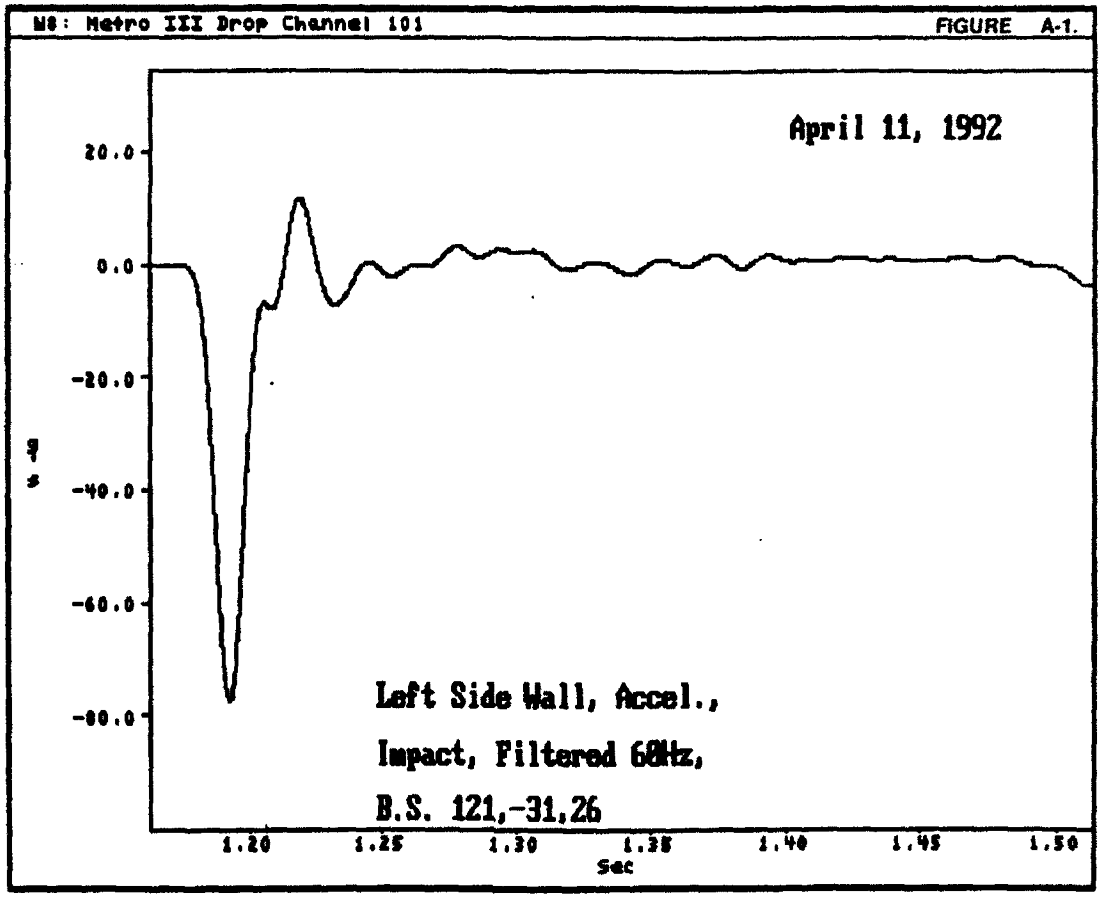
1. Crashworthy commuter category aircraft seats could be developed that keep maximum compressive load measured between the pelvis and the lumbar column of the anthropomorphic dummy below the 1,500-pound injury criteria found in FAR 25.562. This could be accomplished by combining, for example, stroking seat technology with improved seat pan designs as well as energy absorbing cushions.

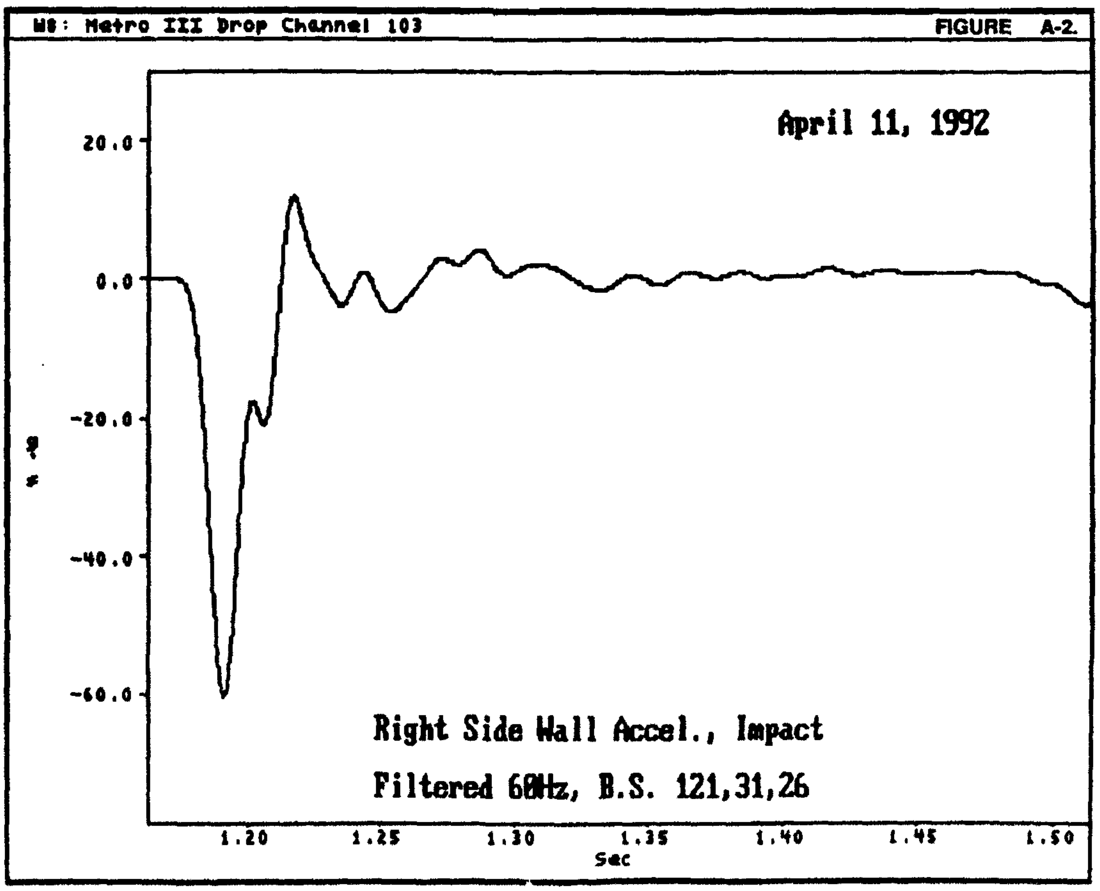
2. This test added considerable valuable data to the commuter airplane data base under survivable crash conditions.

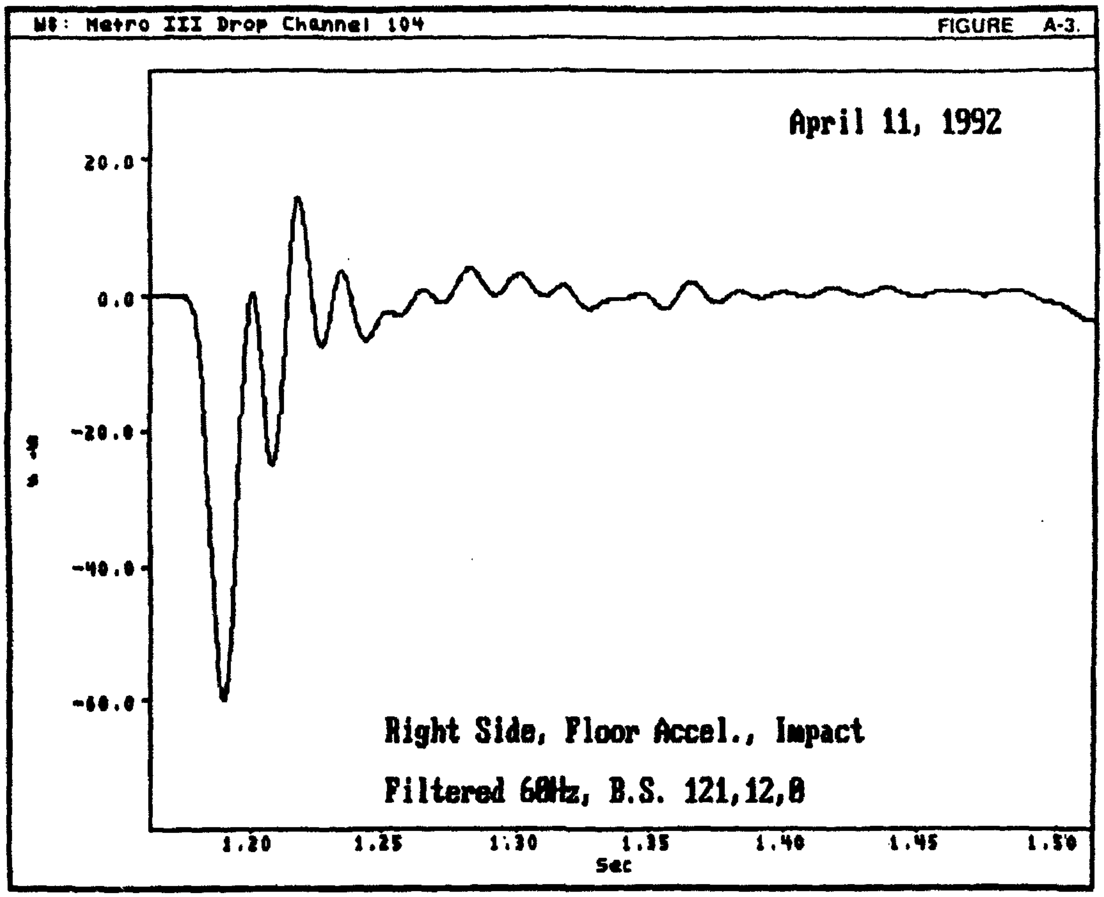
3. This test demonstrated that under the impact condition evaluated the airframe can provide a protective shell for its occupants and that aircraft seats could be readily designed to withstand the impact without collapse while limiting the pelvic/lumbar column load on their occupants to non injurious levels.

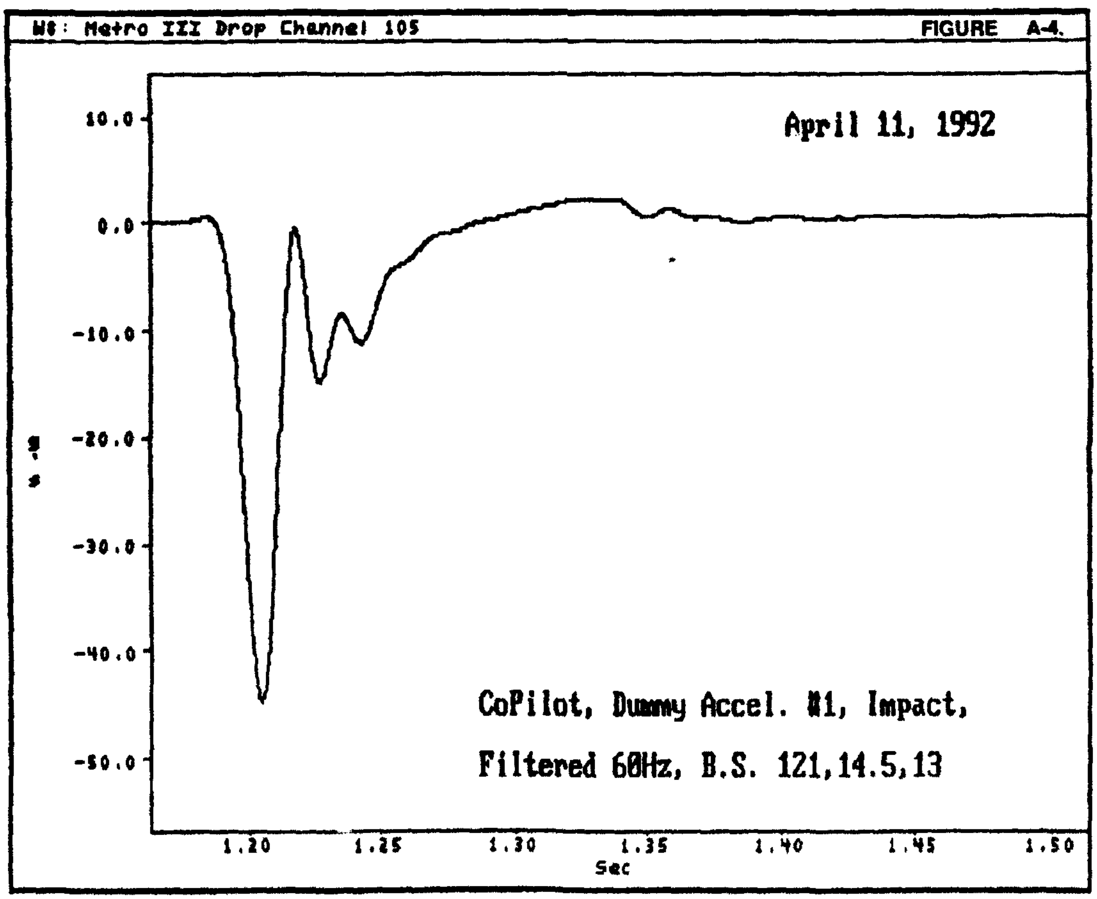
APPENDIX A

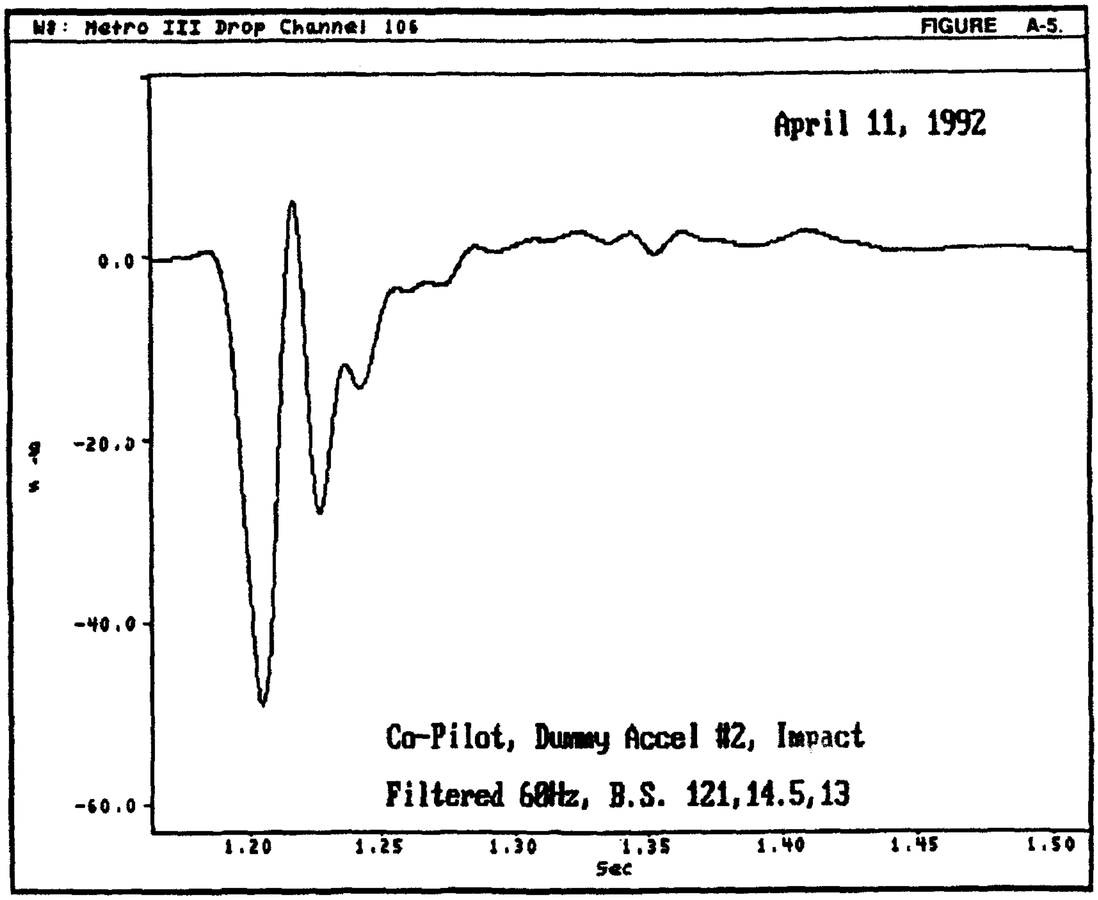
DATA GRAPHS

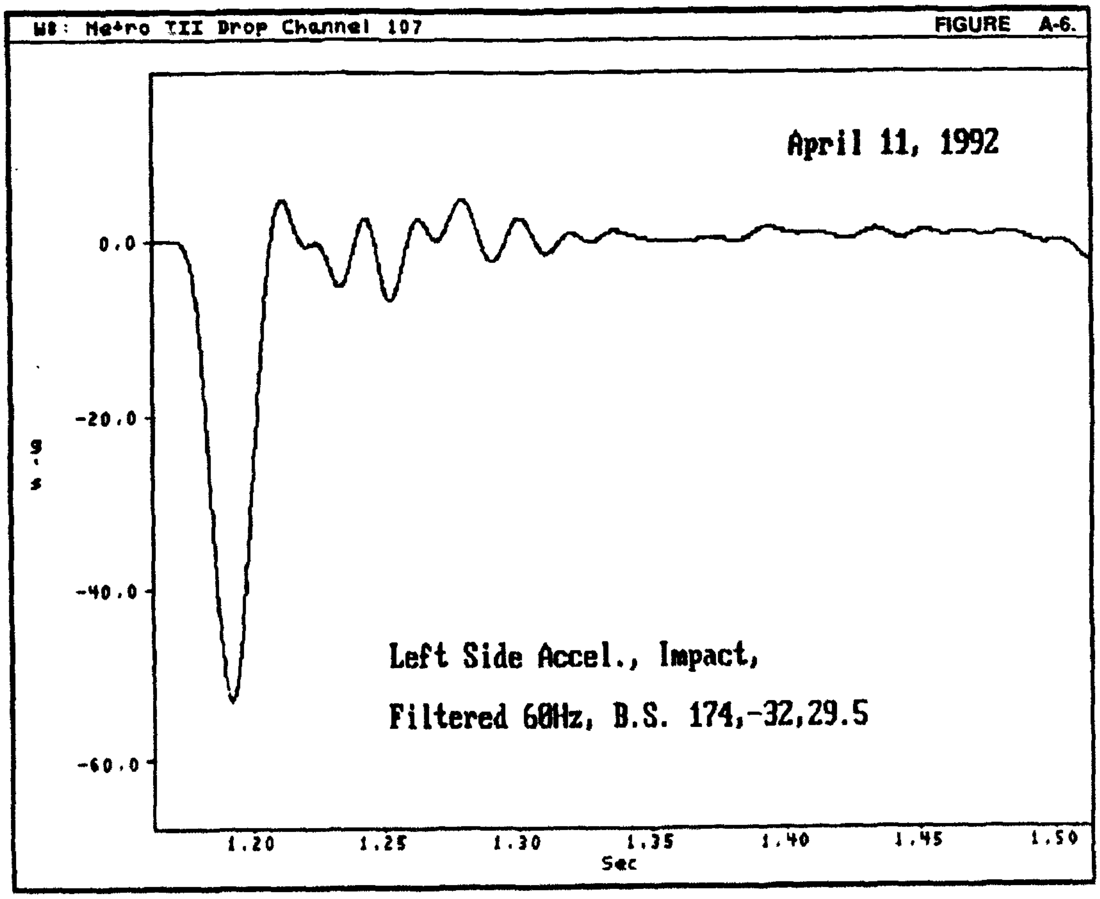

W8: Metro III Drop Channel 101
FIGURE A-1.
April 11, 1992
20.0
0.0
-20.0
-40.0
-60.0
-80.0
g's
Left Side Wall, Accel.,
Impact, Filtered 60Hz,
B.S. 121,-31,26
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

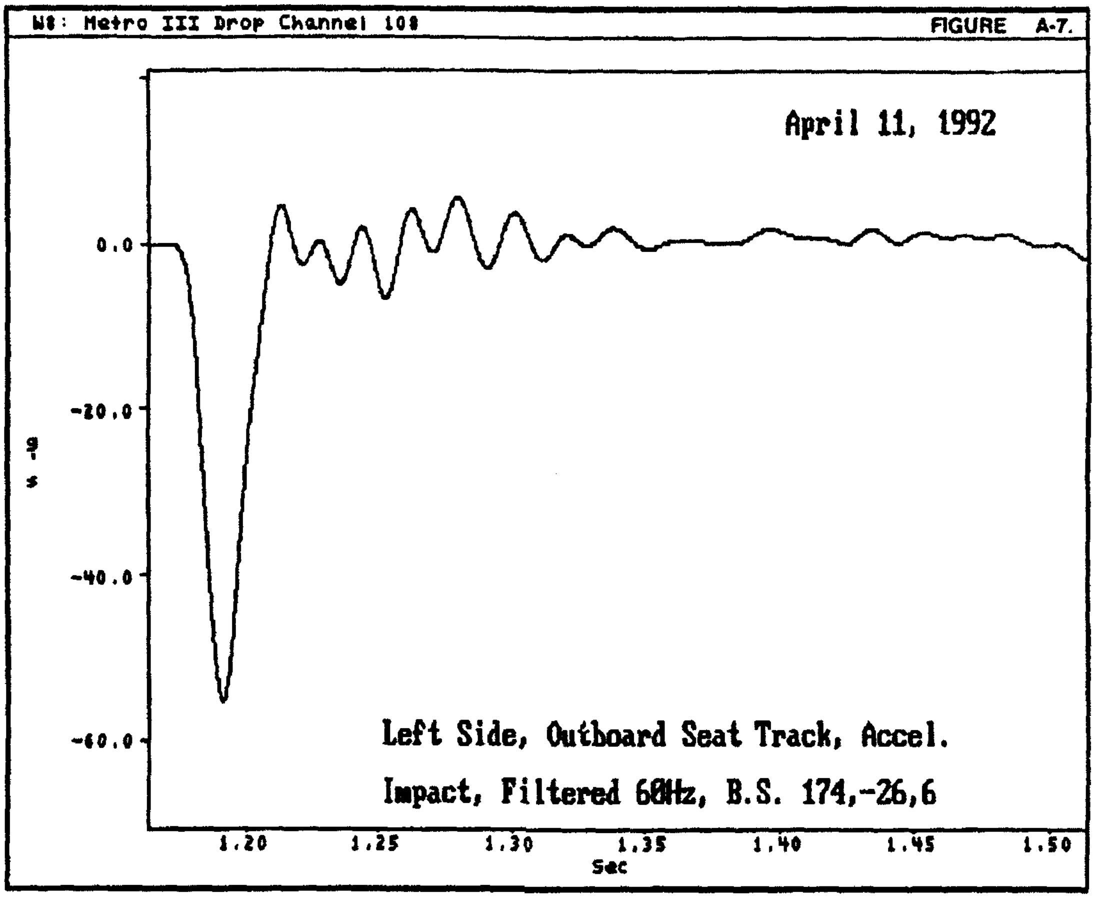

W8: Metro III Drop Channel 103
FIGURE A-2.
April 11, 1992
20.0
0.0
-20.0
-40.0
-60.0
g's
Right Side Wall Accel., Impact
Filtered 60Hz, B.S. 121,31,26
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

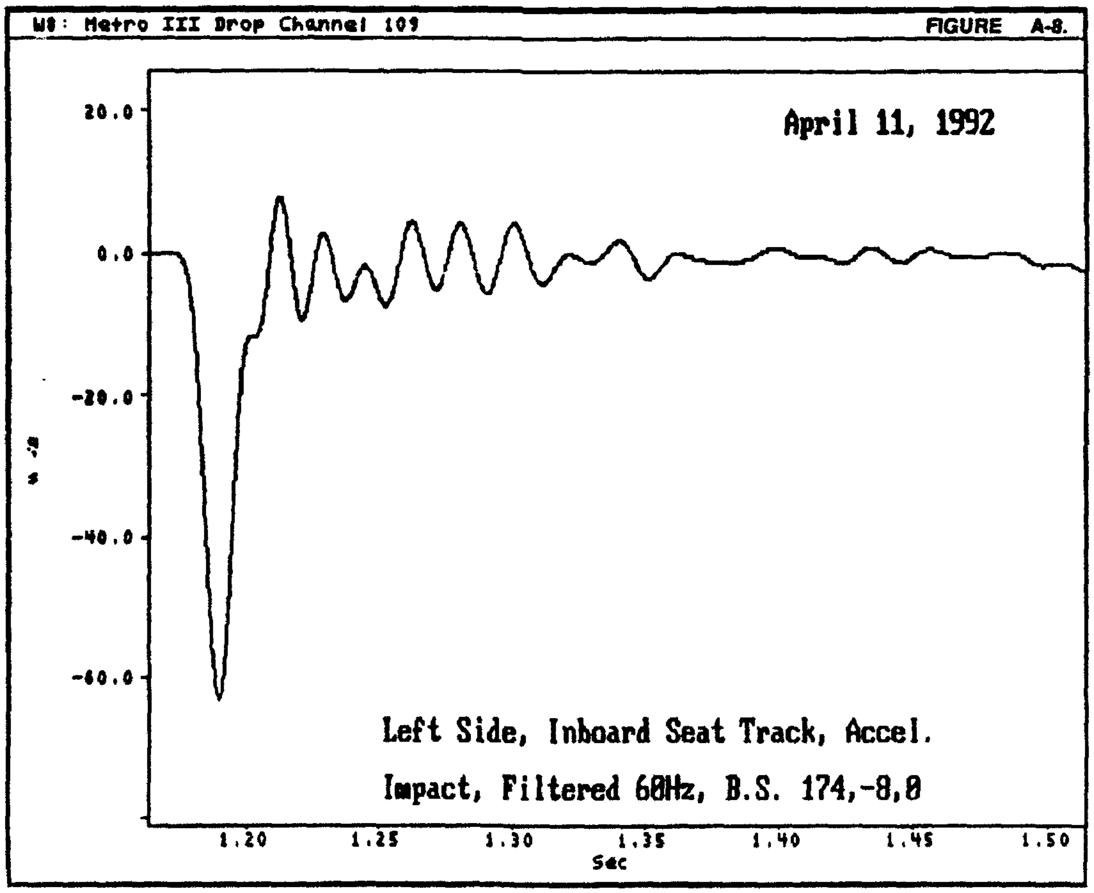

W8: Metro III Drop Channel 104
FIGURE A-3.
April 11, 1992
20.0
0.0
-20.0
-40.0
-60.0
g's
Right Side, Floor Accel., Impact
Filtered 60Hz, B.S. 121,12,0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

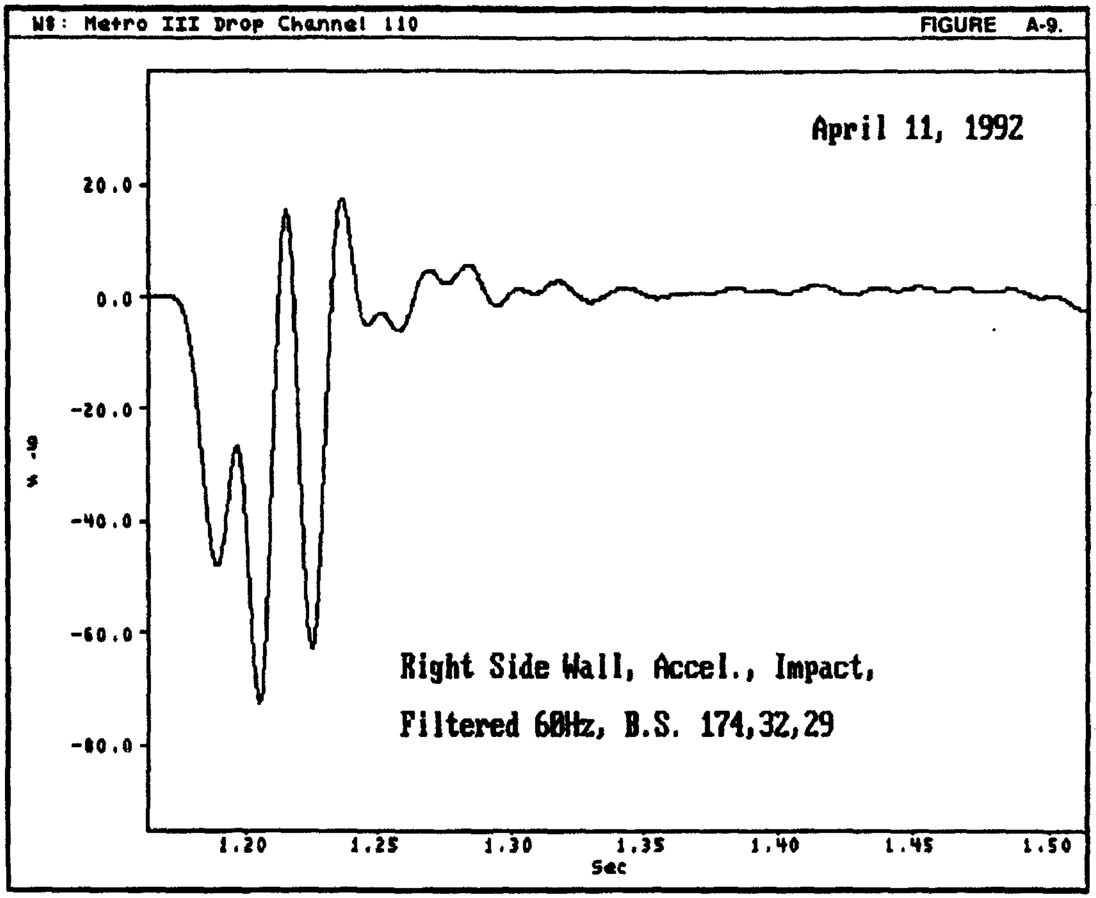

W8: Metro III Drop Channel 105
FIGURE A-4.
April 11, 1992
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
g's
CoPilot, Dummy Accel. #1, Impact,
Filtered 60Hz, B.S. 121,14.5,13
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

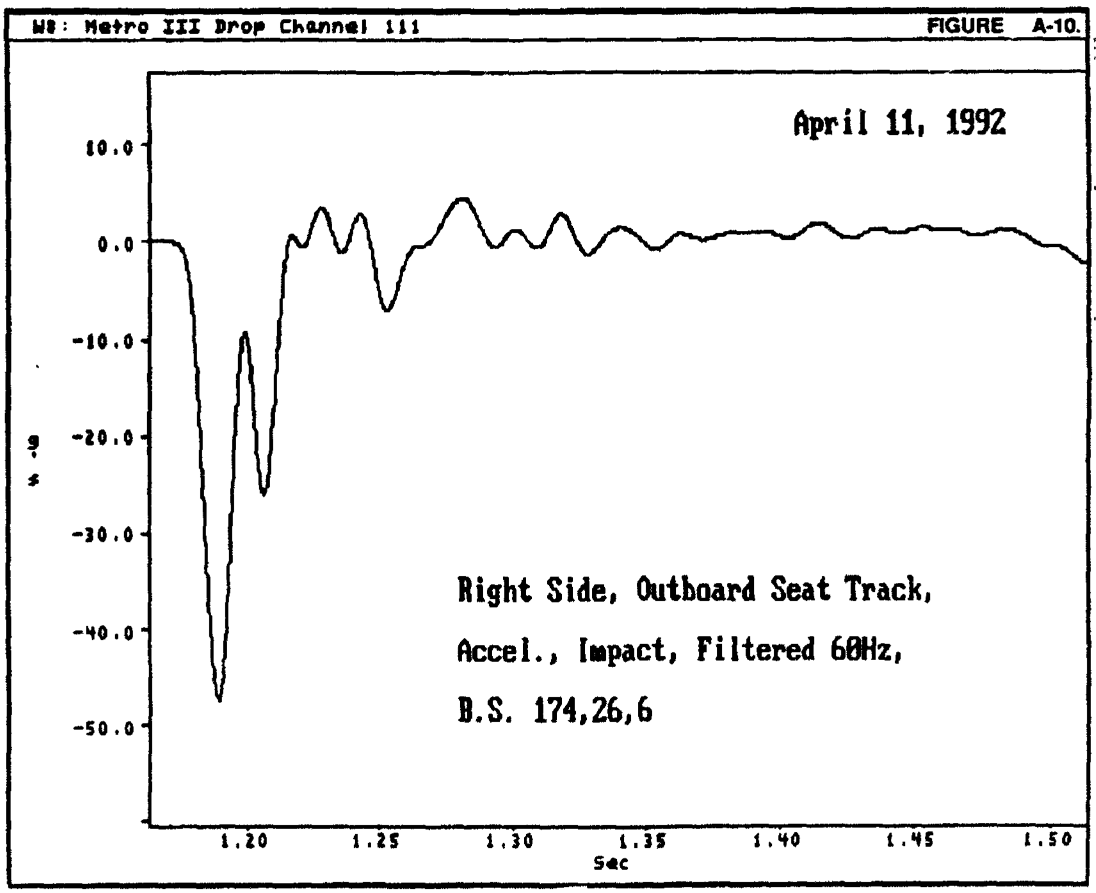

W8: Metro III Drop Channel 106
FIGURE A-5.
April 11, 1992
0.0
-20.0
-40.0
-60.0
g's
Co-Pilot, Dummy Accel #2, Impact
Filtered 60Hz, B.S. 121,14.5,13
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

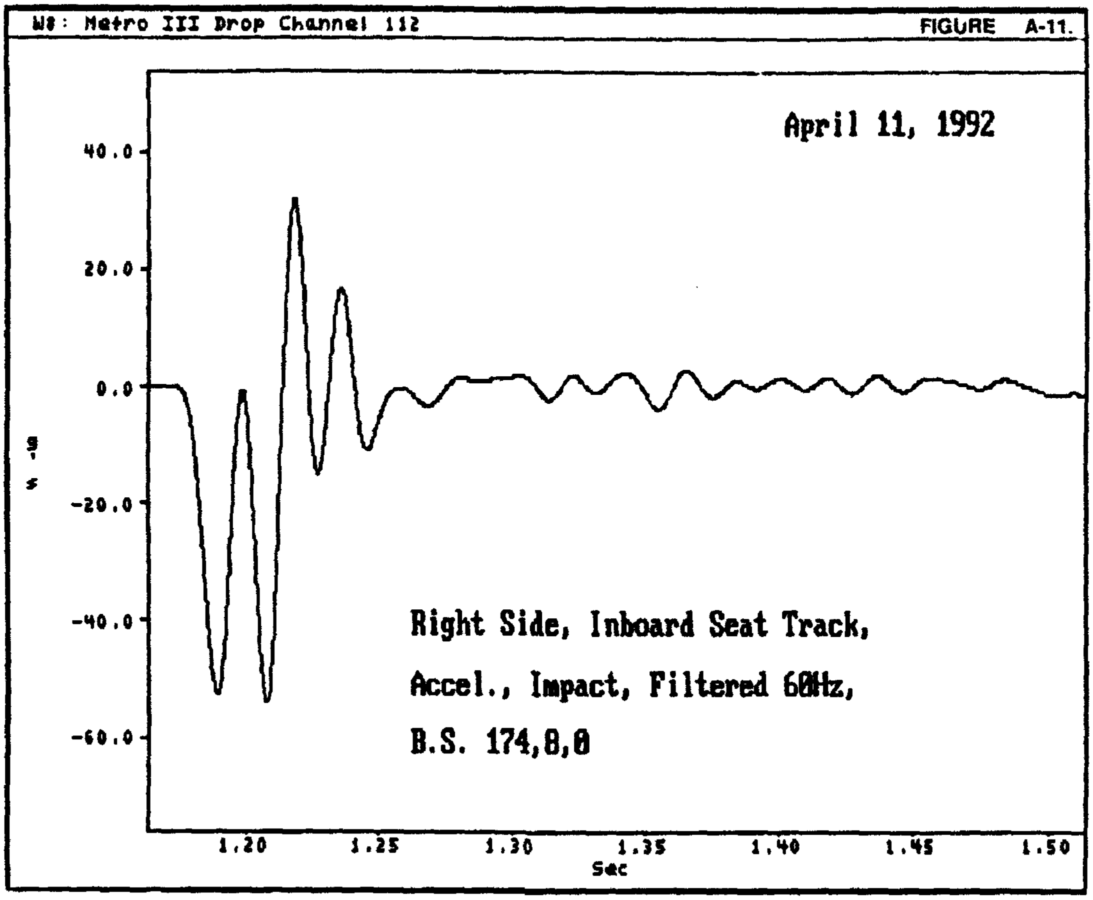

W8: Metro III Drop Channel 107
FIGURE A-6.
April 11, 1992
0.0
-20.0
-40.0
-60.0
g's
Left Side Accel., Impact,
Filtered 60Hz, B.S. 174,-32,29.5
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

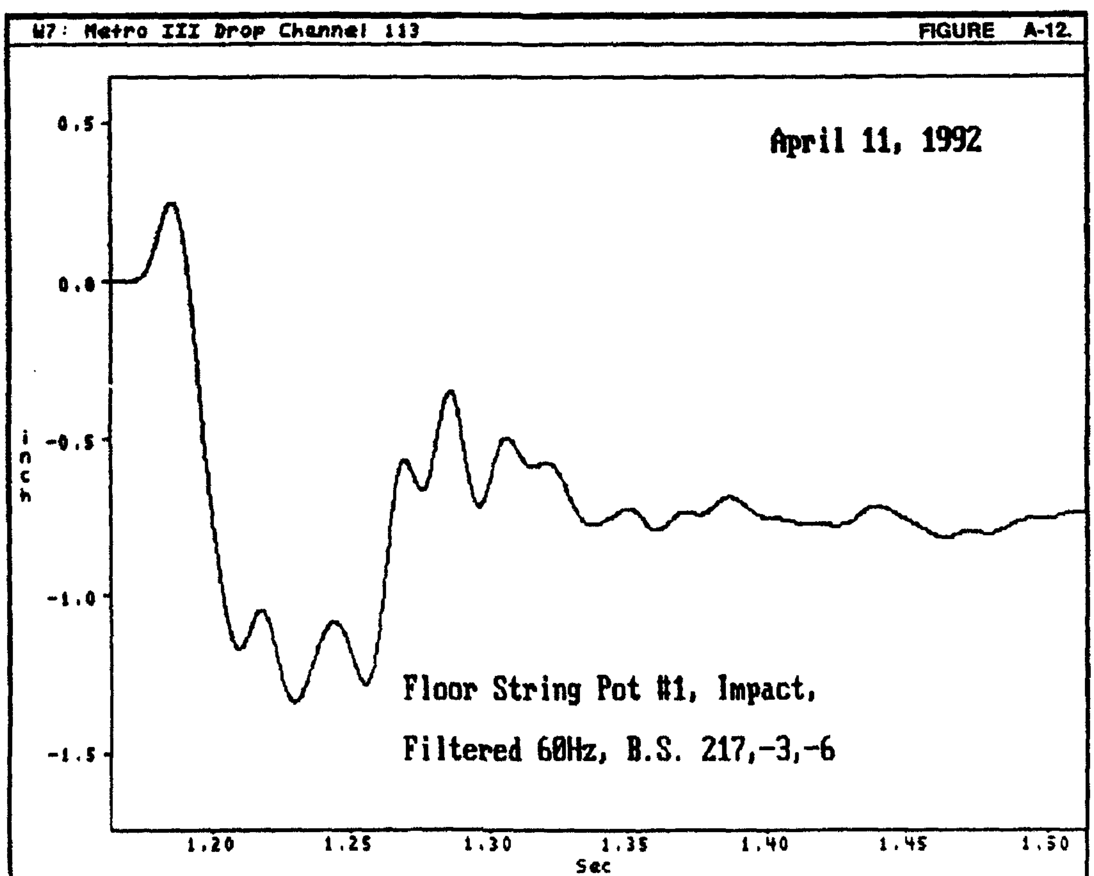

W8: Metro III Drop Channel 108
FIGURE A-7.
April 11, 1992
0.0
-20.0
-40.0
-60.0
g's
Left Side, Outboard Seat Track, Accel.
Impact, Filtered 60Hz, B.S. 174,-26,6
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

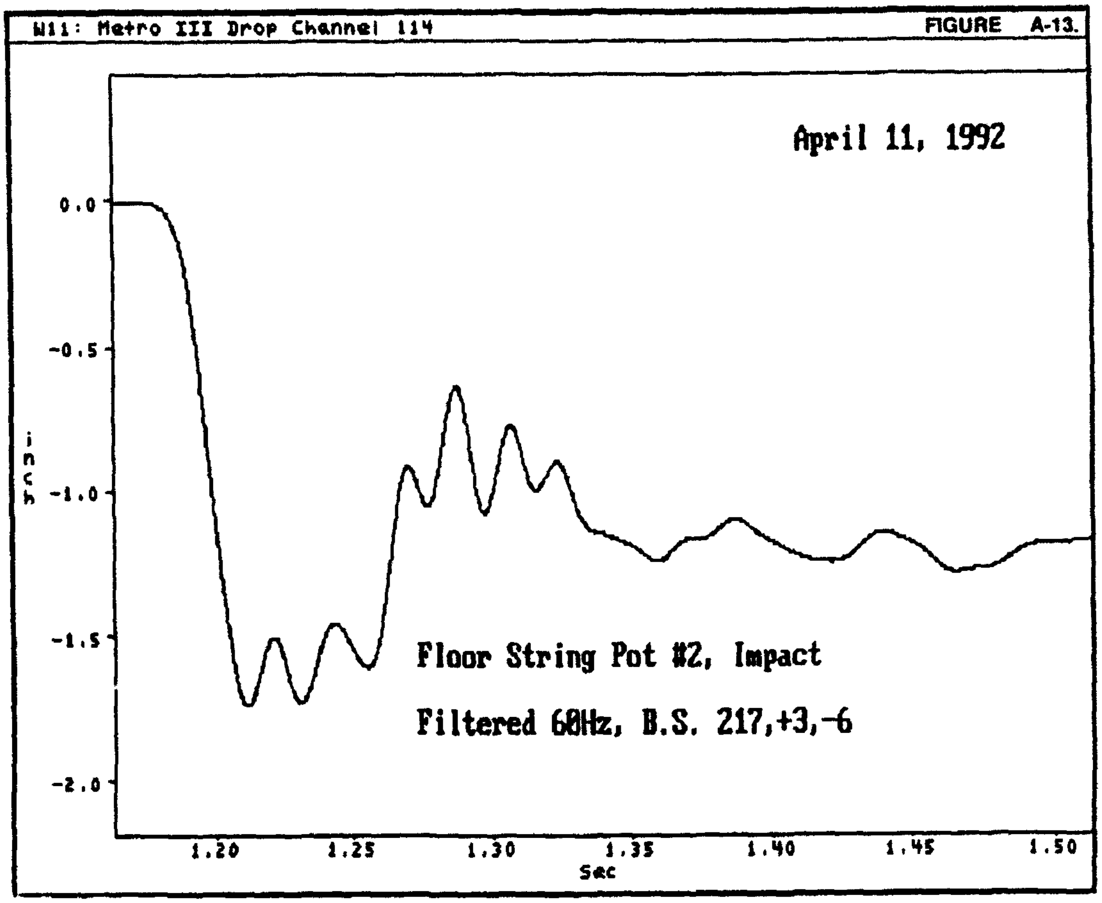

W8: Metro III Drop Channel 109
FIGURE A-8.
April 11, 1992
20.0
0.0
-20.0
-40.0
-60.0
g's
Left Side, Inboard Seat Track, Accel.
Impact, Filtered 60Hz, B.S. 174,-8,0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

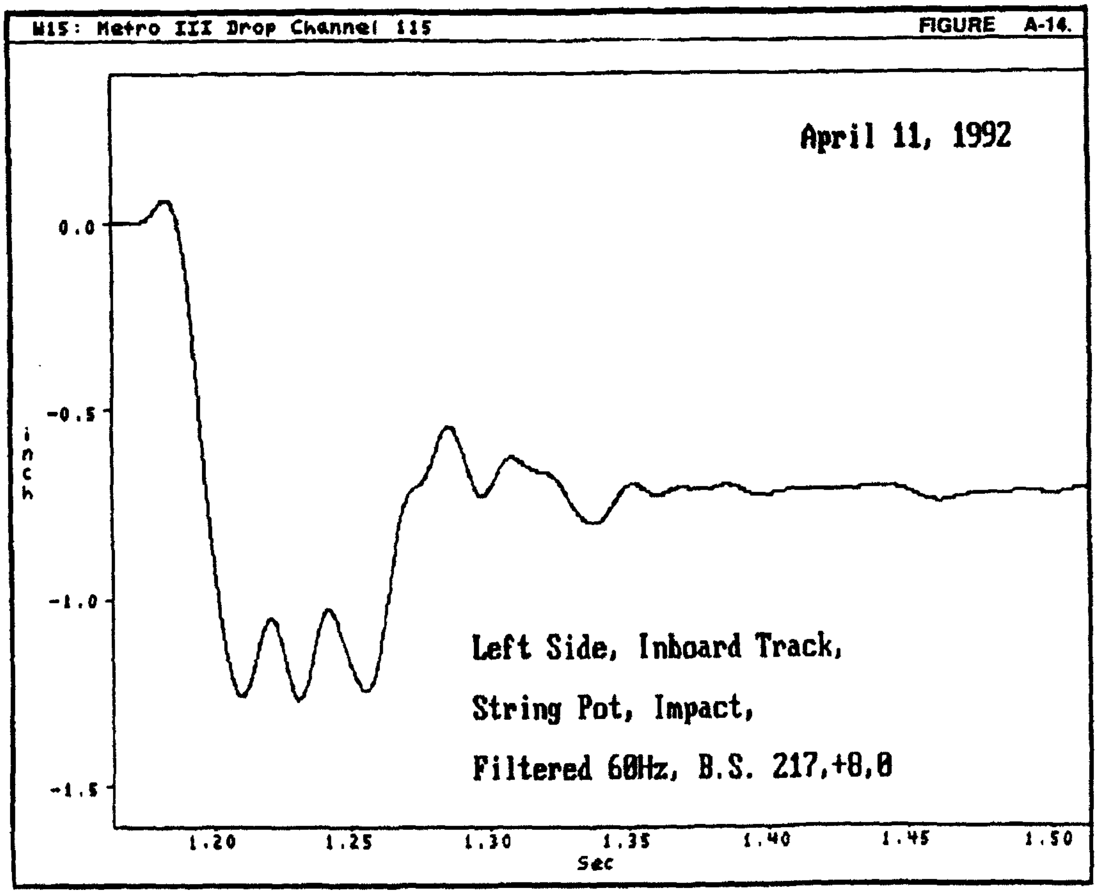

W8: Metro III Drop Channel 110
FIGURE A-9.
April 11, 1992
20.0
0.0
-20.0
-40.0
-60.0
-80.0
g's
Right Side Wall, Accel., Impact,
Filtered 60Hz, B.S. 174,32,29
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

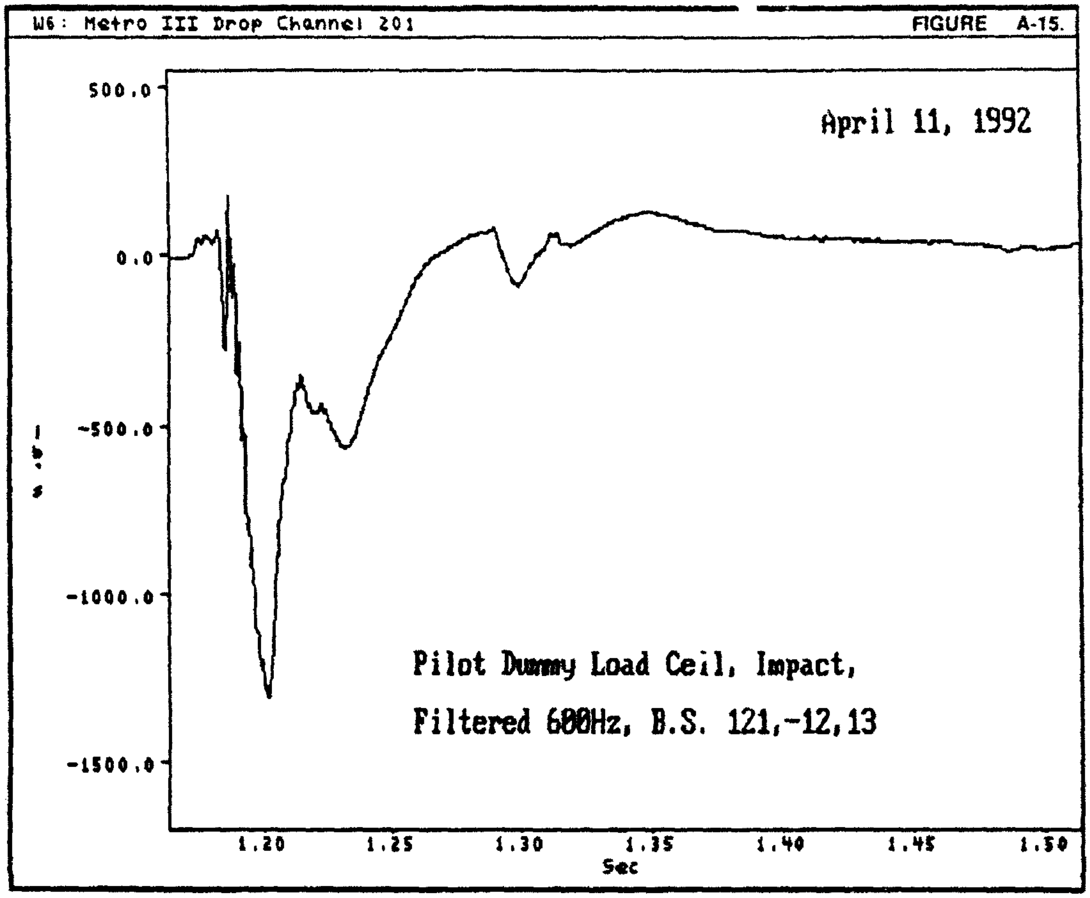

W8: Metro III Drop Channel 111
FIGURE A-10.
April 11, 1992
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
g's
Right Side, Outboard Seat Track,
Accel., Impact, Filtered 60Hz,
B.S. 174,26,6
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

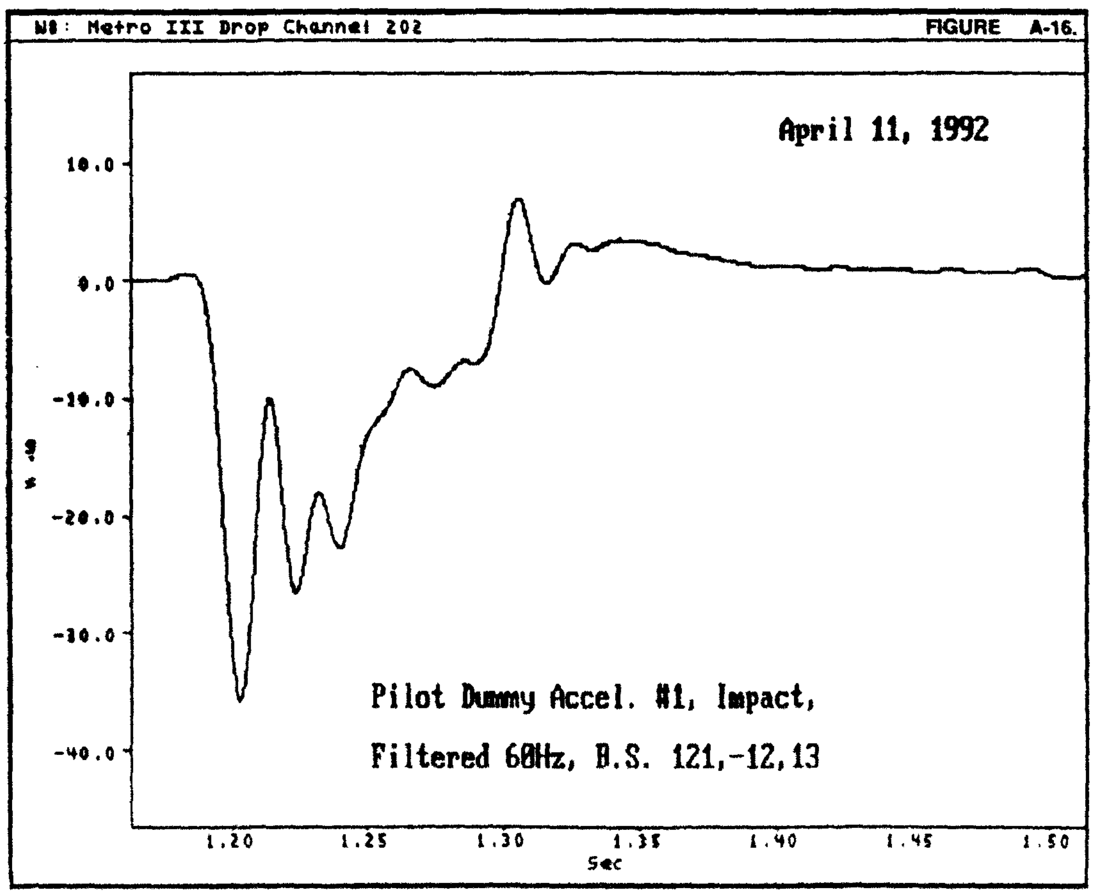

W8: Metro III Drop Channel 112
FIGURE A-11.
April 11, 1992
40.0
20.0
0.0
-20.0
-40.0
-60.0
g's
Right Side, Inboard Seat Track,
Accel., Impact, Filtered 60Hz,
B.S. 174,0,0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

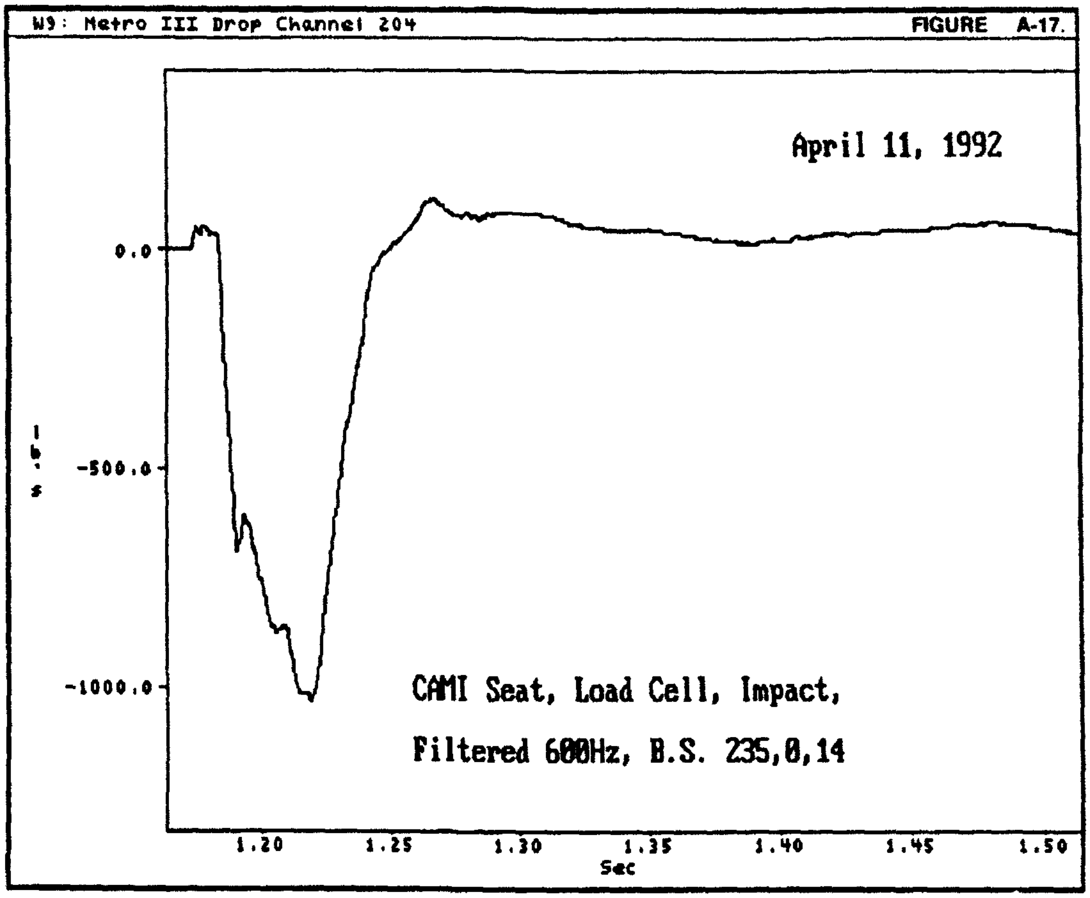

W7: Metro III Drop Channel 113
FIGURE A-12.
April 11, 1992
0.5
0.0
-0.5
-1.0
-1.5
inch
Floor String Pot #1, Impact,
Filtered 60Hz, B.S. 217,-3,-6
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

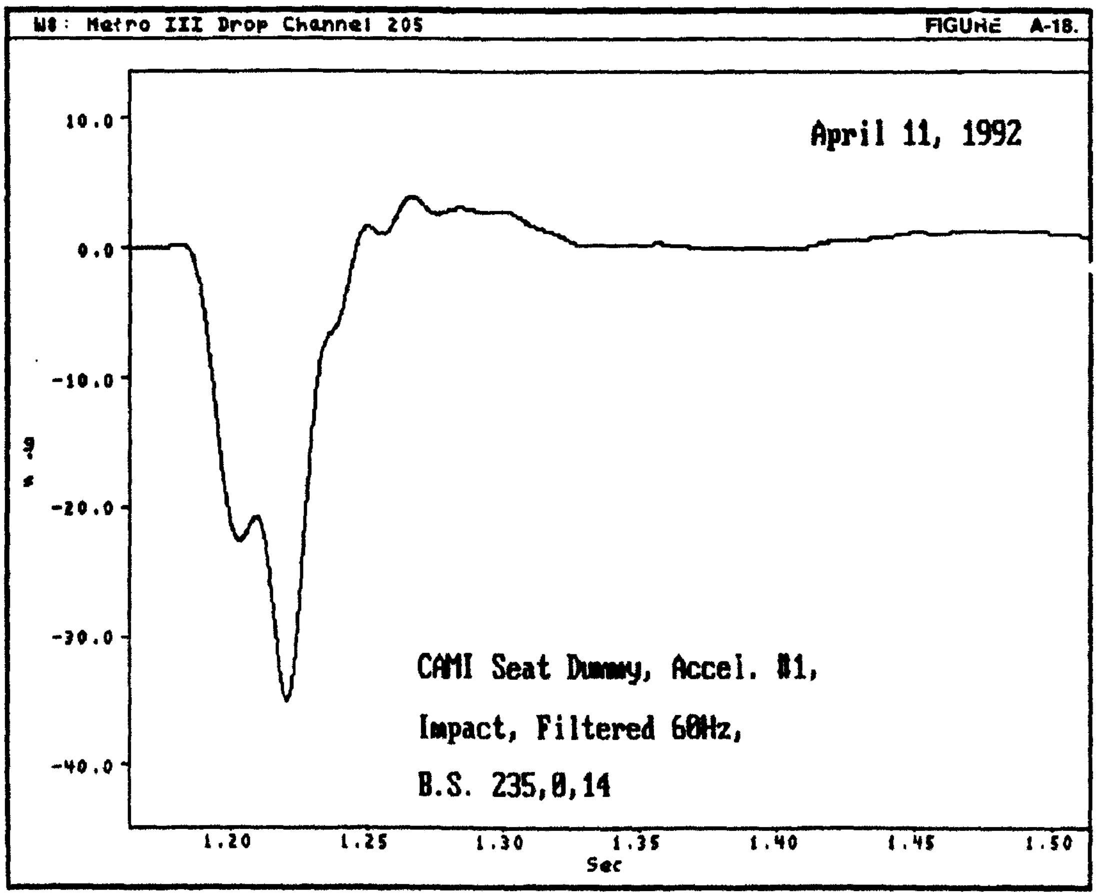

W11: Metro III Drop Channel 114
FIGURE A-13.
April 11, 1992
0.0
-0.5
-1.0
-1.5
-2.0
inch
Floor String Pot #2, Impact
Filtered 60Hz, B.S. 217,+3,-6
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

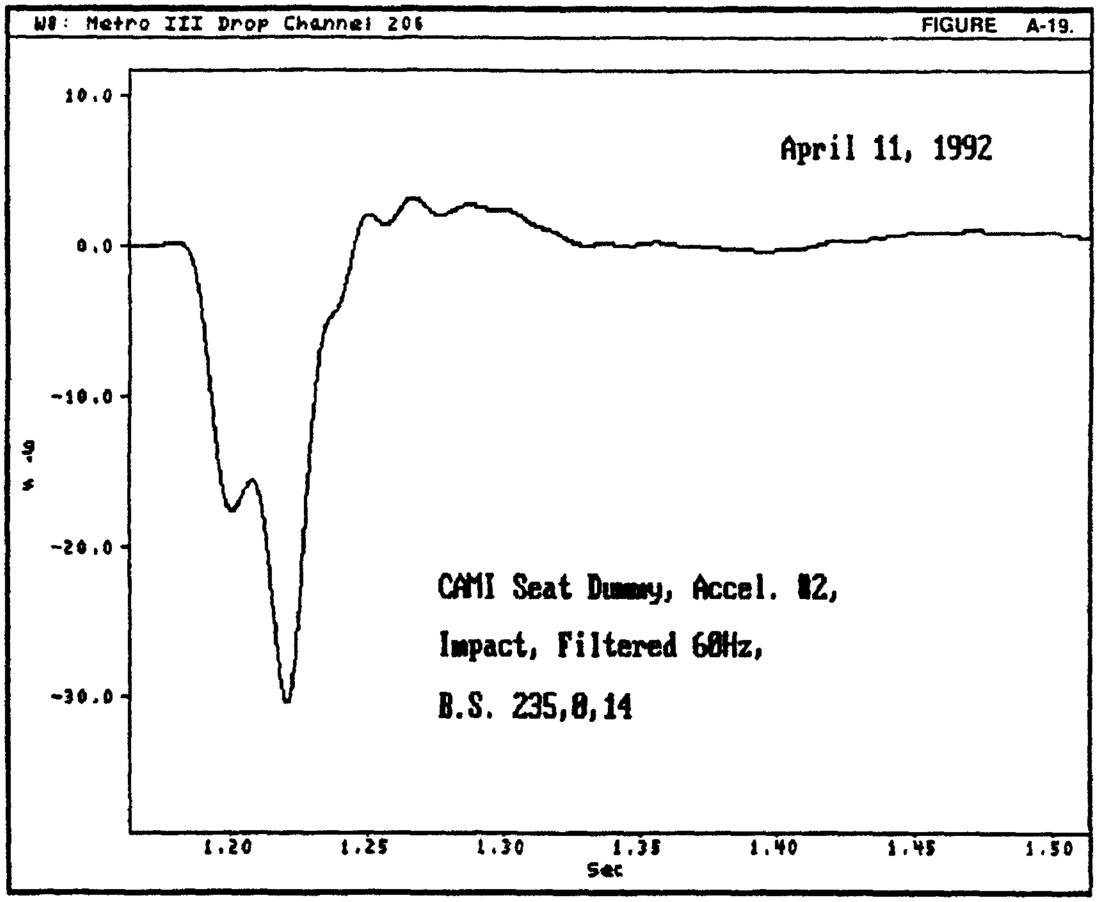

W15: Metro III Drop Channel 115
FIGURE A-14.
April 11, 1992
0.0
-0.5
-1.0
-1.5
inch
Left Side, Inboard Track,
String Pot, Impact,
Filtered 60Hz, B.S. 217,+8,0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

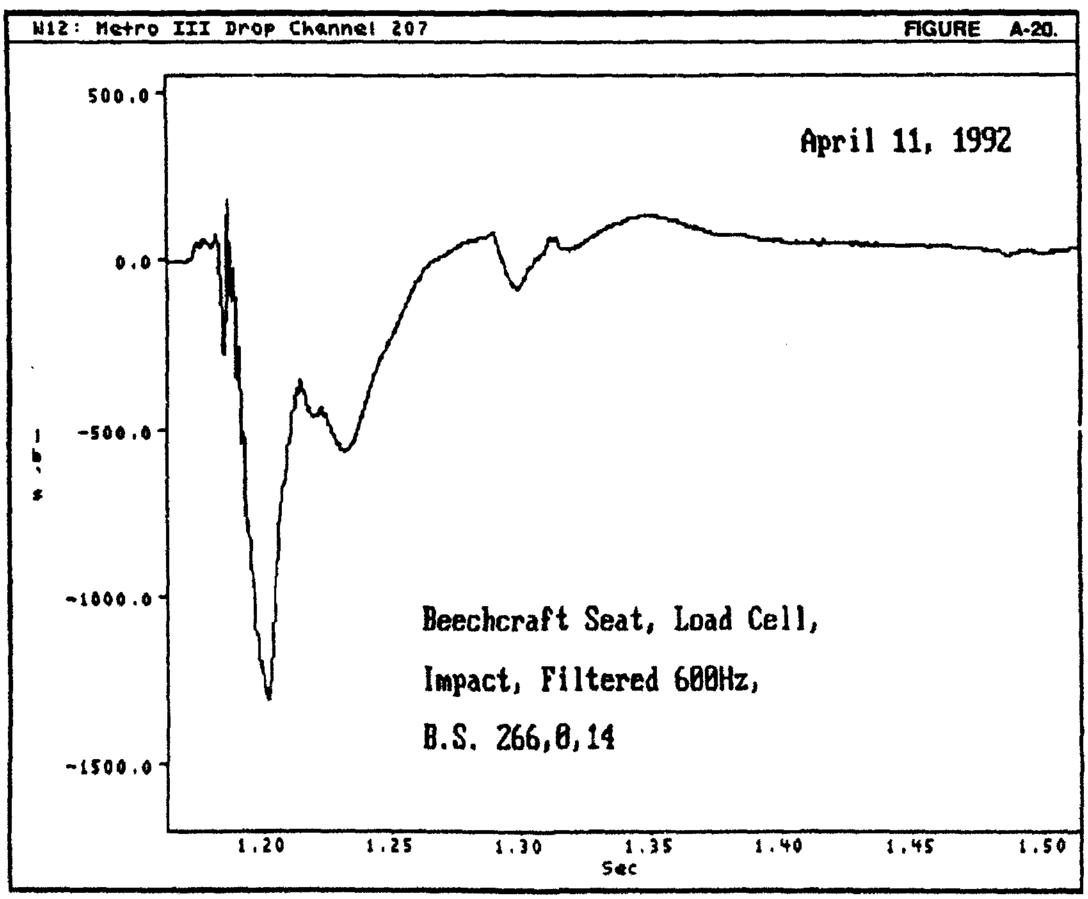

W6: Metro III Drop Channel 201
FIGURE A-15.
April 11, 1992
Pilot Dummy Load Cell, Impact,
Filtered 600Hz, B.S. 121,-12,13
500.0
0.0
-500.0
-1000.0
-1500.0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

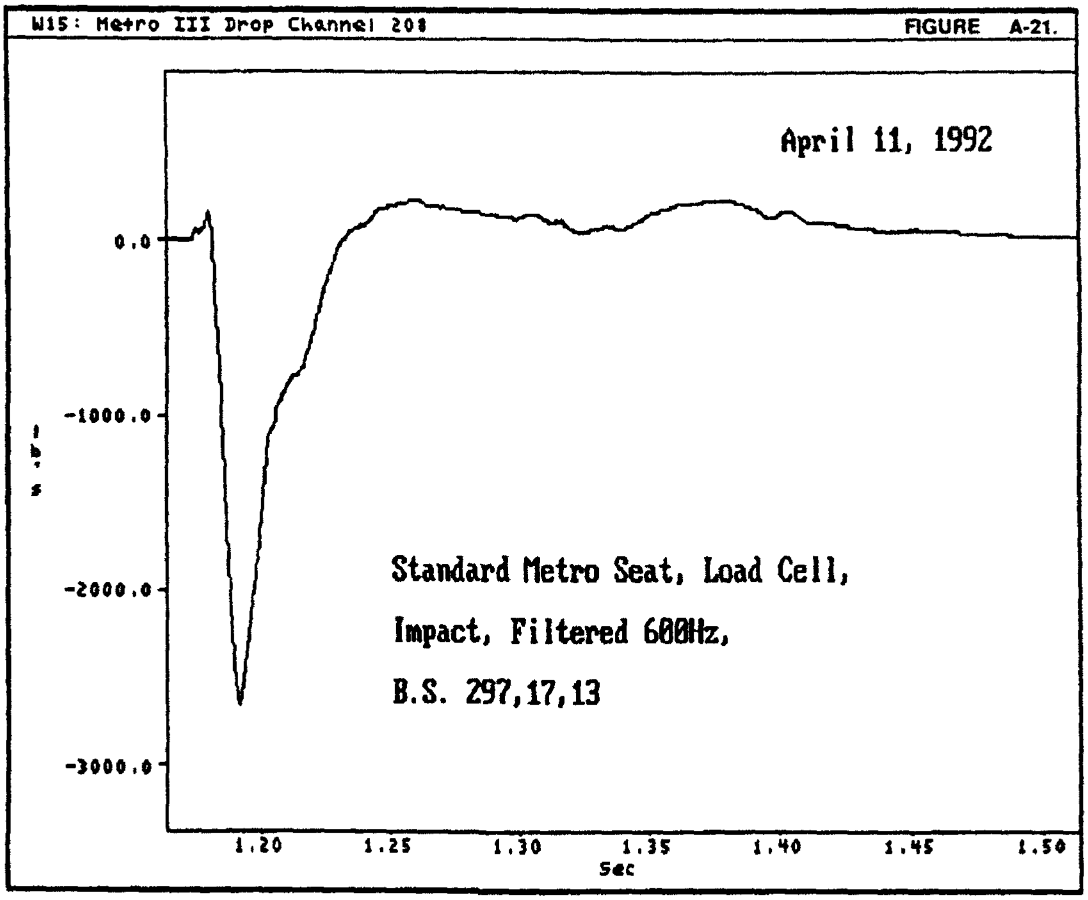

W8: Metro III Drop Channel 202
FIGURE A-16.
April 11, 1992
Pilot Dummy Accel. #1, Impact,
Filtered 60Hz, B.S. 121,-12,13
10.0
0.0
-10.0
-20.0
-30.0
-40.0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

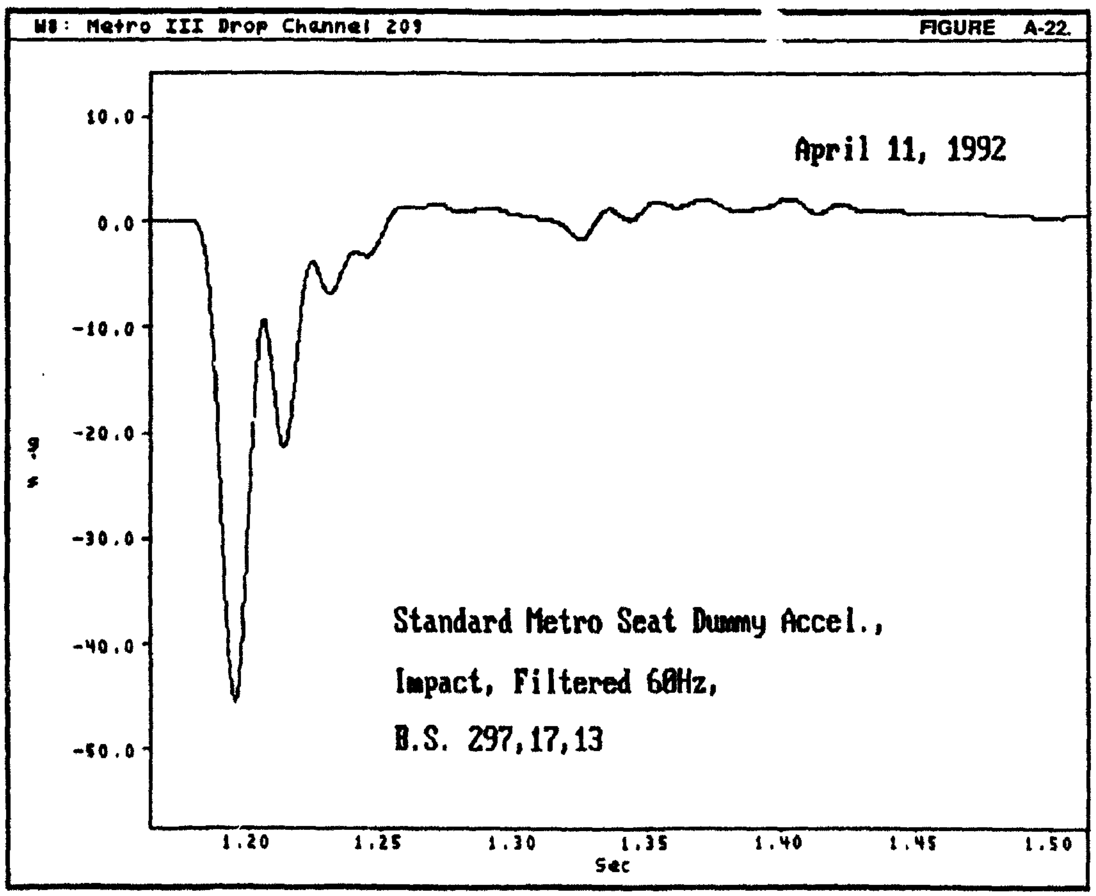

W9: Metro III Drop Channel 204
FIGURE A-17.
April 11, 1992
0.0
-500.0
-1000.0
lbs
CAMI Seat, Load Cell, Impact,
Filtered 600Hz, B.S. 235,0,14
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

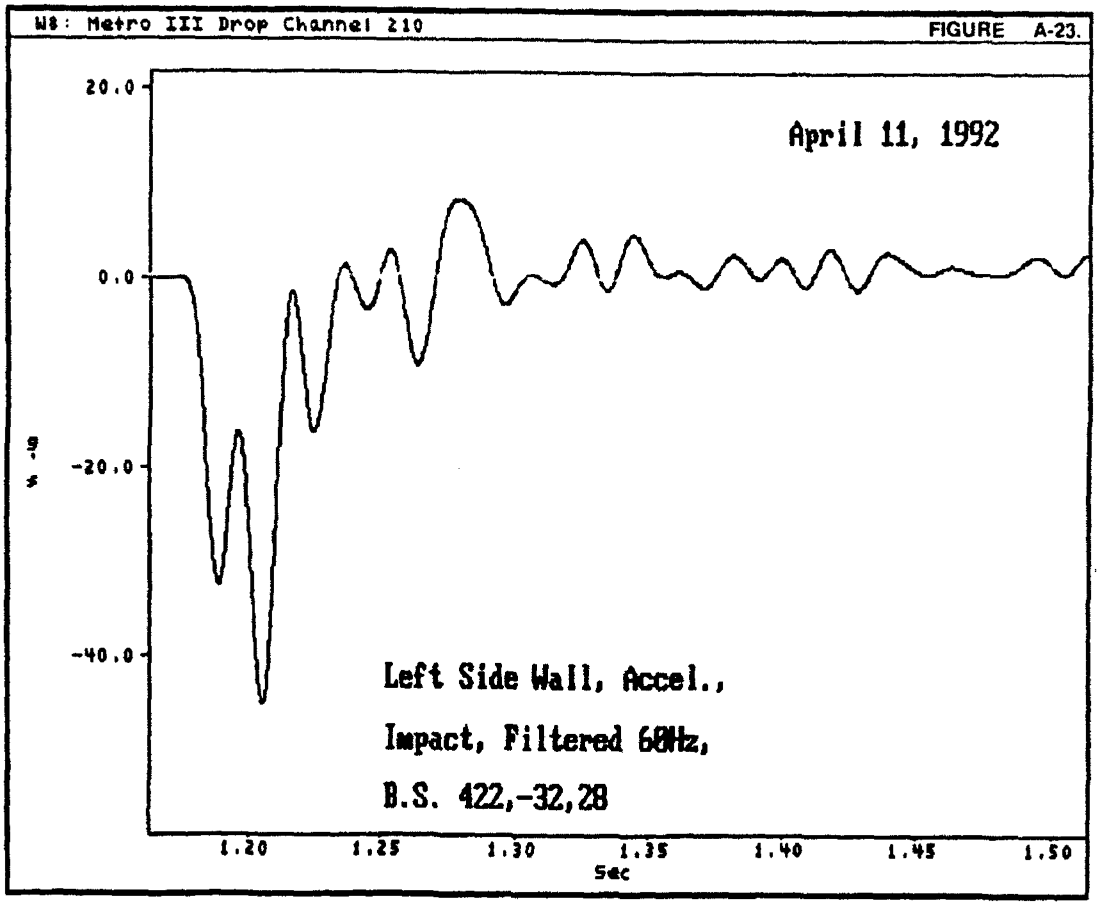

W8: Metro III Drop Channel 205
FIGURE A-18.
10.0
0.0
-10.0
-20.0
-30.0
-40.0
g's
April 11, 1992
CAMI Seat Dummy, Accel. #1,
Impact, Filtered 60Hz,
B.S. 235,0,14
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

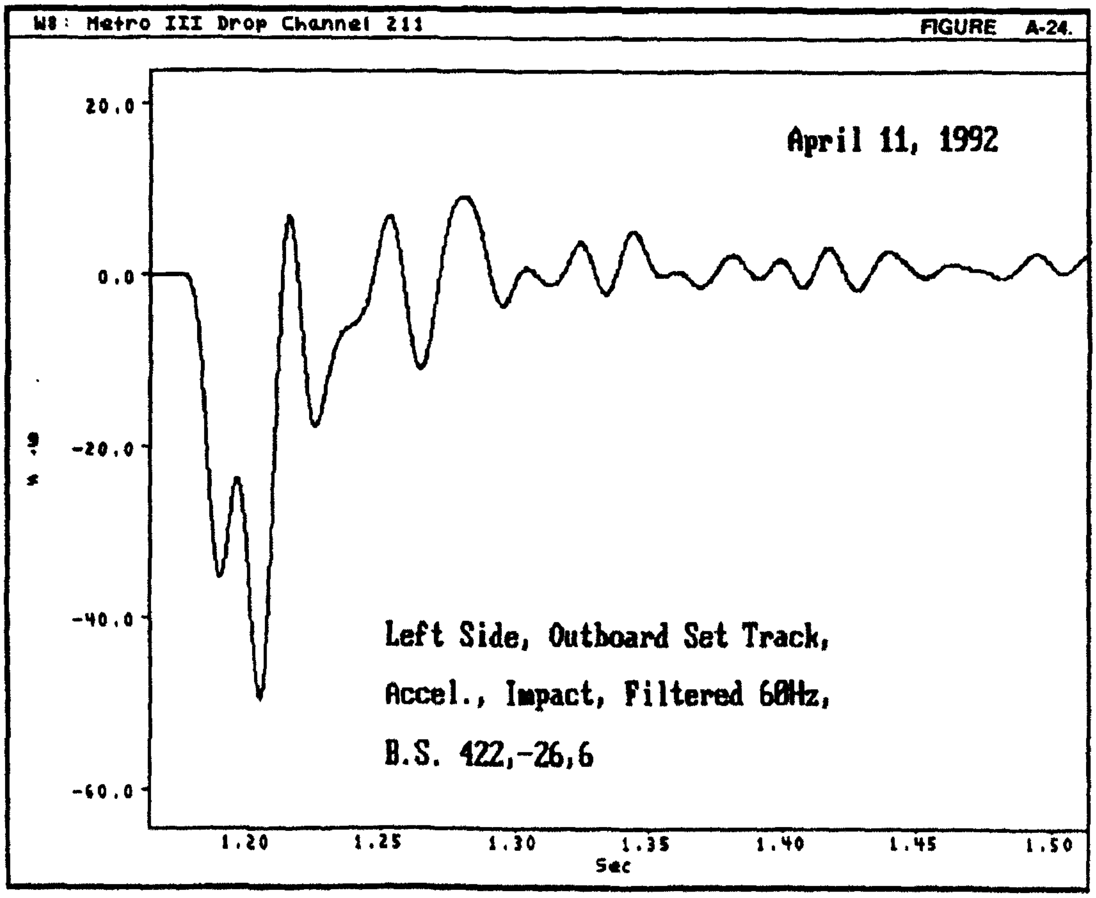

W8: Metro III Drop Channel 206
FIGURE A-19.
April 11, 1992
CAMI Seat Dummy, Accel. #2,
Impact, Filtered 60Hz,
B.S. 235,0,14
10.0
0.0
-10.0
-20.0
-30.0
g's
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

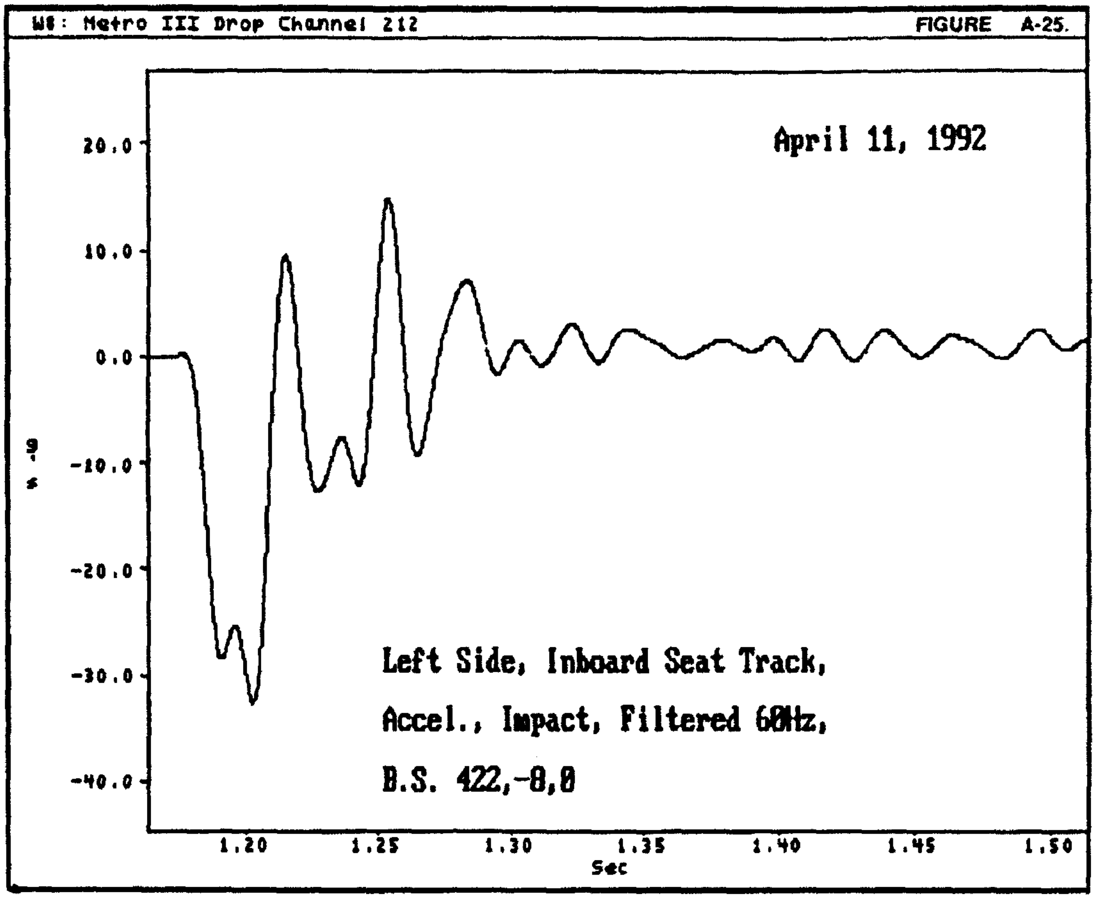

W12: Metro III Drop Channel 207
FIGURE A-20.
April 11, 1992
Beechcraft Seat, Load Cell,
Impact, Filtered 600Hz,
B.S. 266,0,14
500.0
0.0
-500.0
-1000.0
-1500.0
lb's
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec


W15: Metro III Drop Channel 208
FIGURE A-21.
April 11, 1992
0.0
-1000.0
-2000.0
-3000.0
lbs
Standard Metro Seat, Load Cell,
Impact, Filtered 600Hz,
B.S. 297,17,13
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

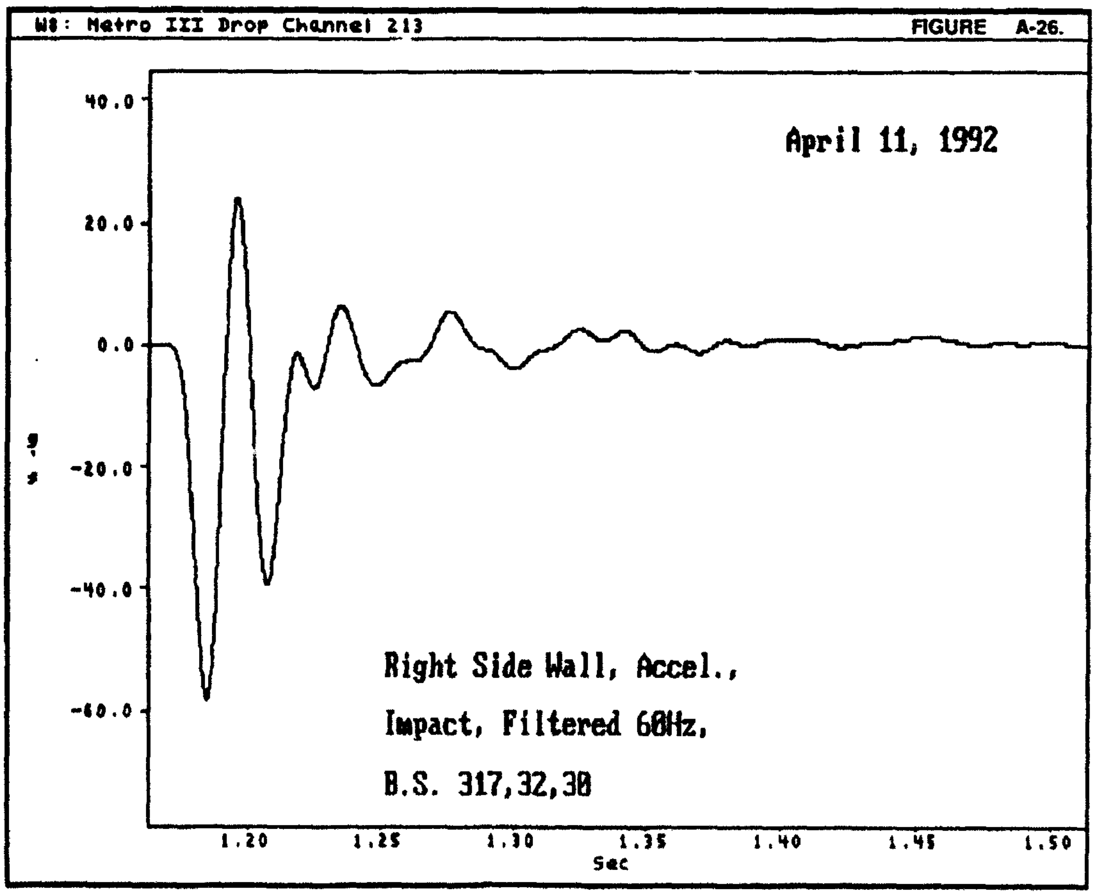

W8: Metro III Drop Channel 209
FIGURE A-22.
April 11, 1992
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
g's
Standard Metro Seat Dummy Accel.,
Impact, Filtered 60Hz,
B.S. 297,17,13
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec


W8: Metro III Drop Channel 210
FIGURE A-23.
April 11, 1992
20.0
0.0
-20.0
-40.0
g's
Left Side Wall, Accel.,
Impact, Filtered 60Hz,
B.S. 422,-32,28
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

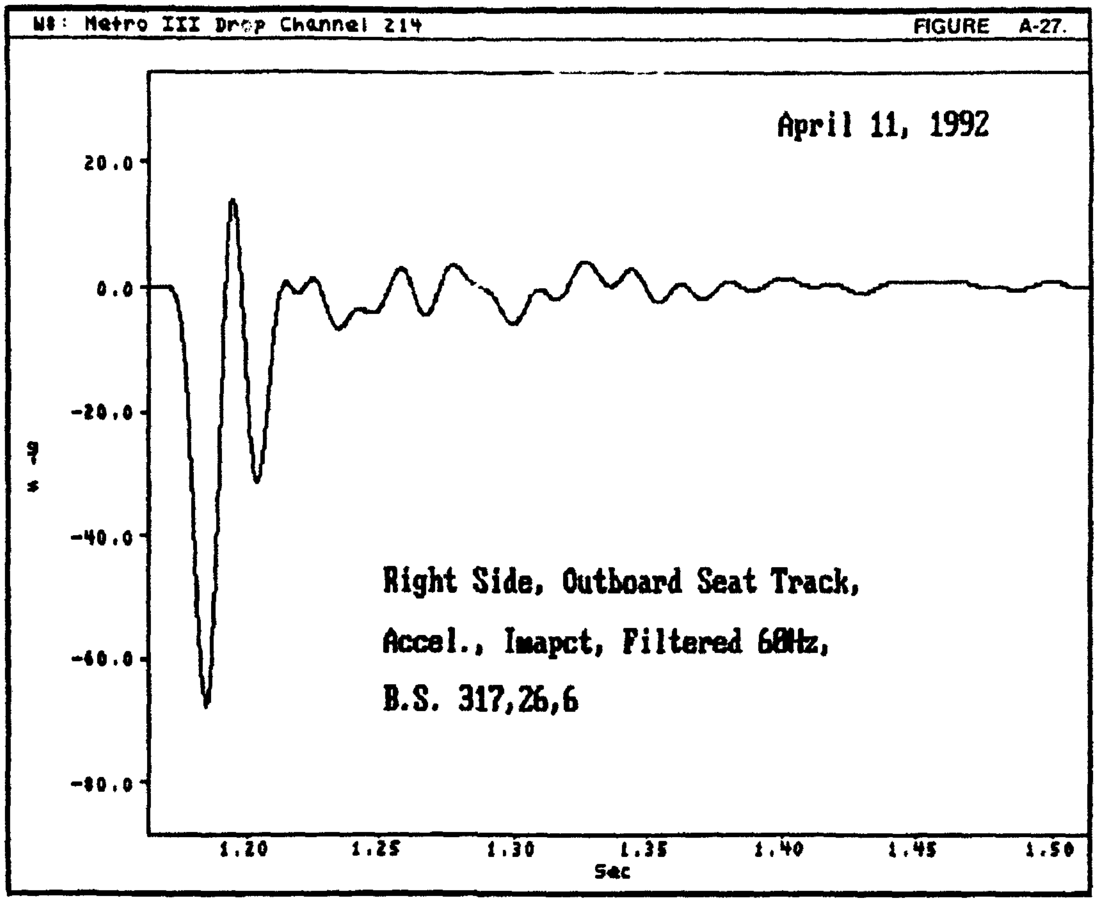

W8: Metro III Drop Channel 211
FIGURE A-24.
April 11, 1992
20.0
0.0
-20.0
-40.0
-60.0
g's
Left Side, Outboard Set Track,
Accel., Impact, Filtered 60Hz,
B.S. 422,-26,6
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec



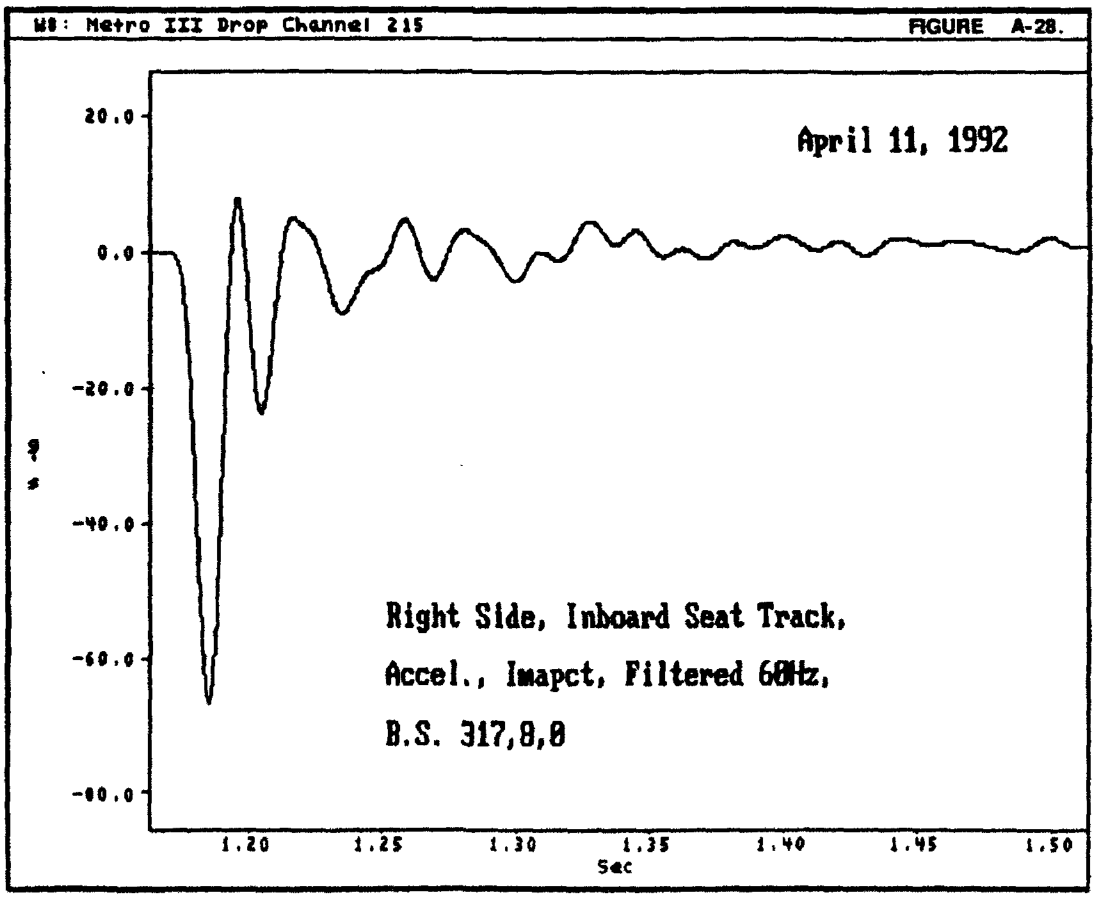
W8: Metro III Drop Channel 212
FIGURE A-25.
April 11, 1992
Left Side, Inboard Seat Track,
Accel., Impact, Filtered 60Hz,
B.S. 422,-8,0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
g's
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec



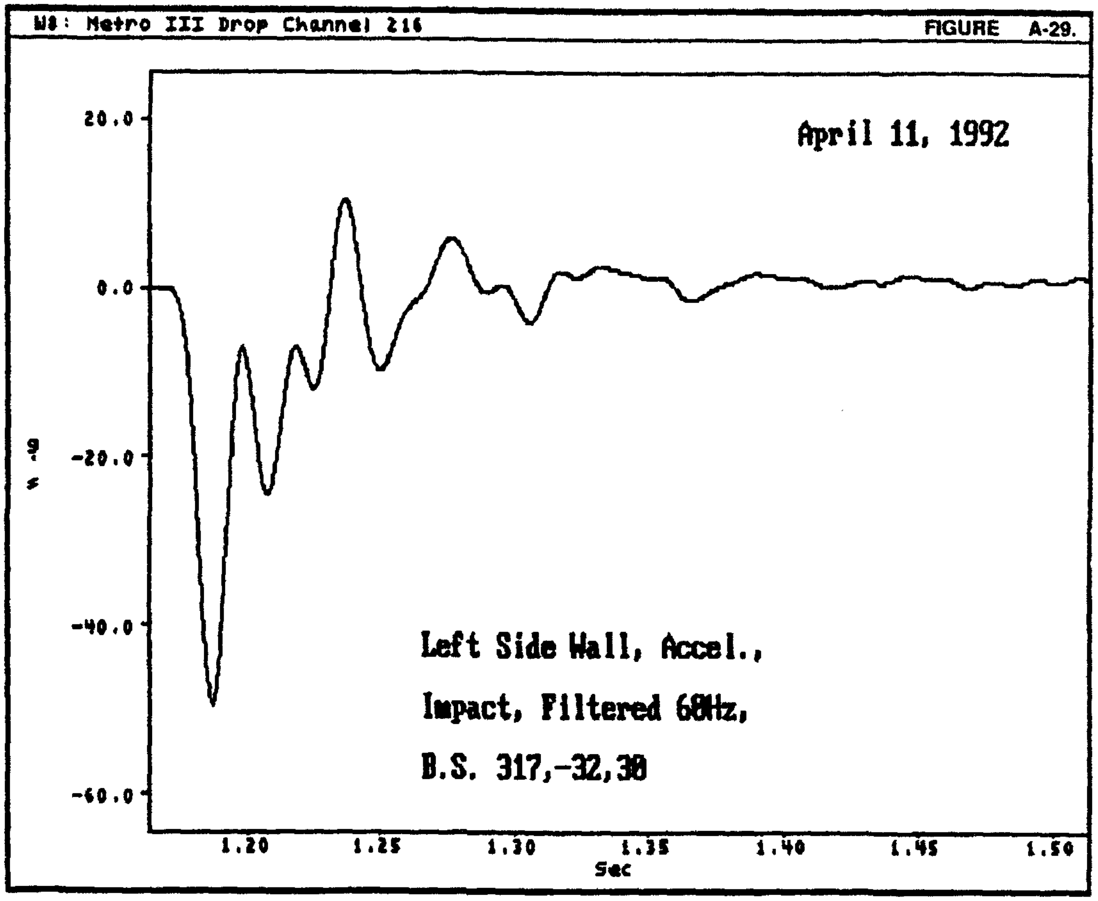
W8: Metro III Drop Channel 213
FIGURE A-26.
April 11, 1992
Right Side Wall, Accel.,
Impact, Filtered 60Hz,
B.S. 317,32,30
40.0
20.0
0.0
-20.0
-40.0
-60.0
g's
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

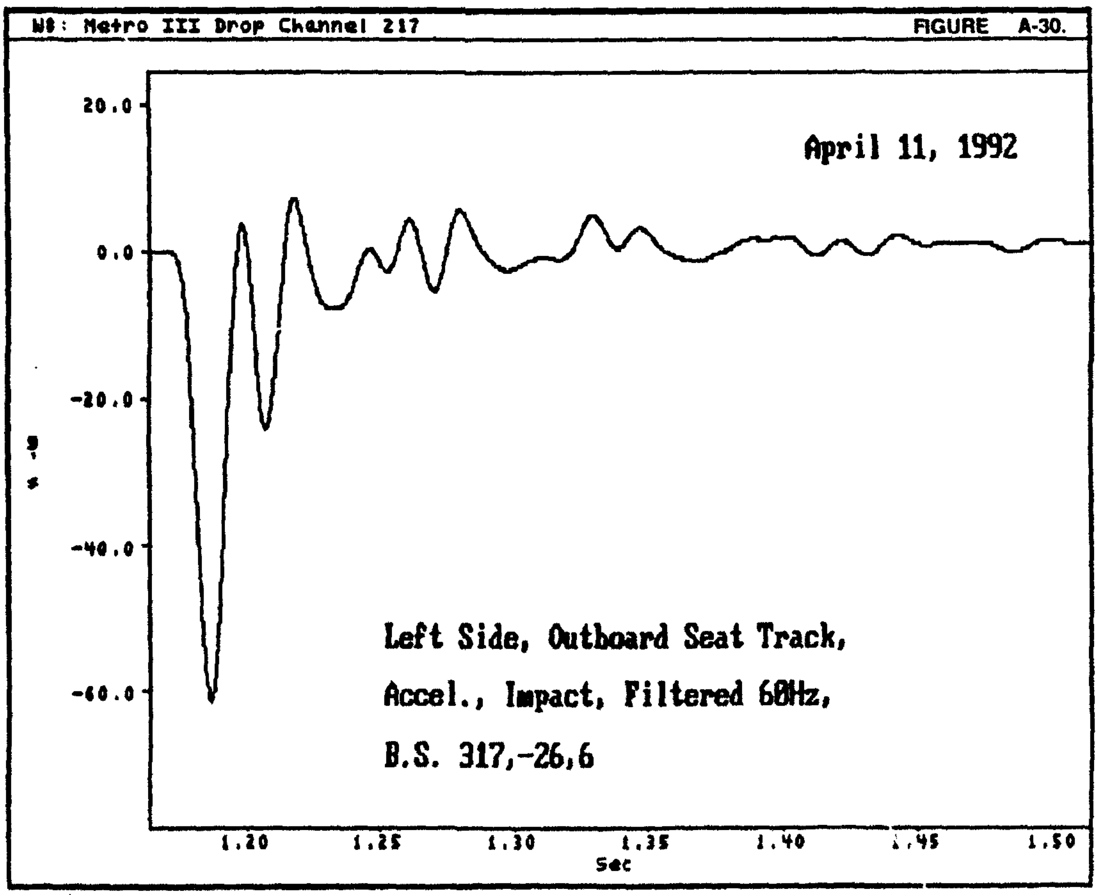


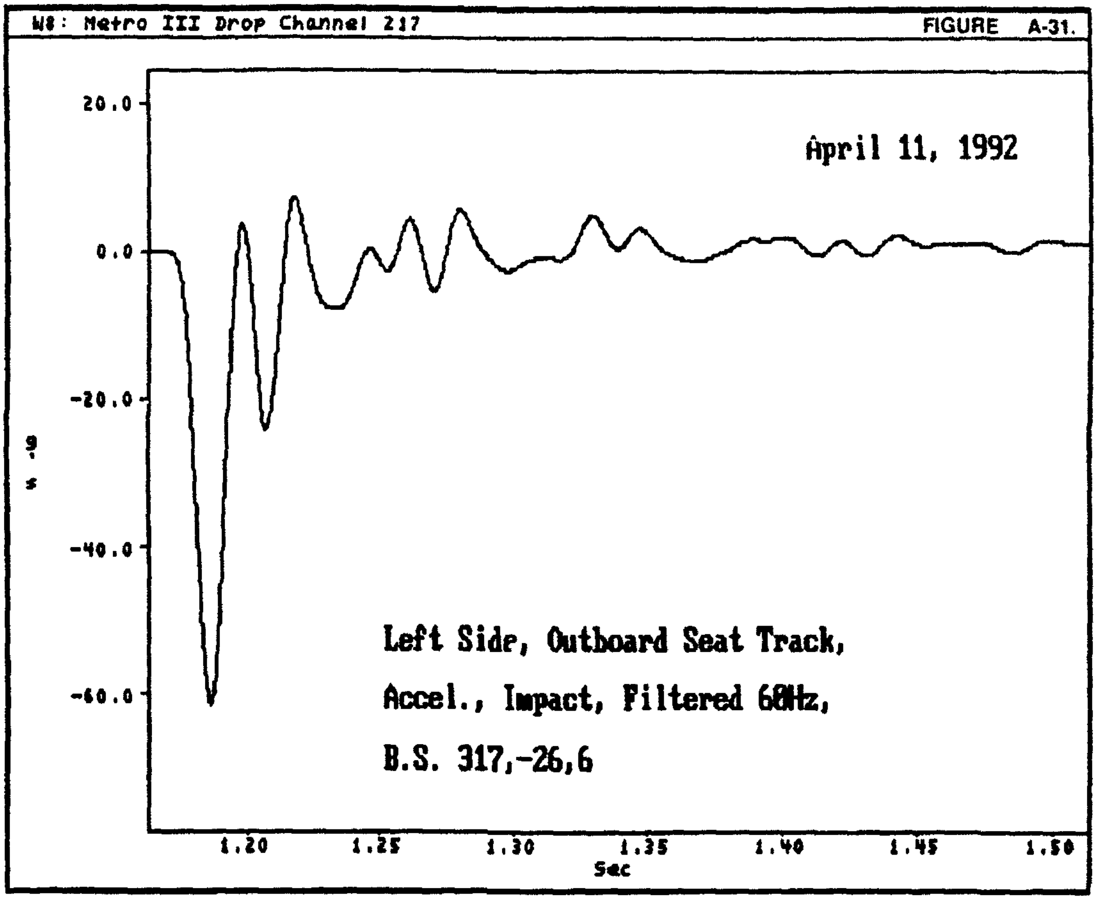
W8: Metro III Drop Channel 214
FIGURE A-27.
April 11, 1992
Right Side, Outboard Seat Track,
Accel., Imapct, Filtered 60Hz,
B.S. 317,26,6
g's
20.0
0.0
-20.0
-40.0
-60.0
-80.0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

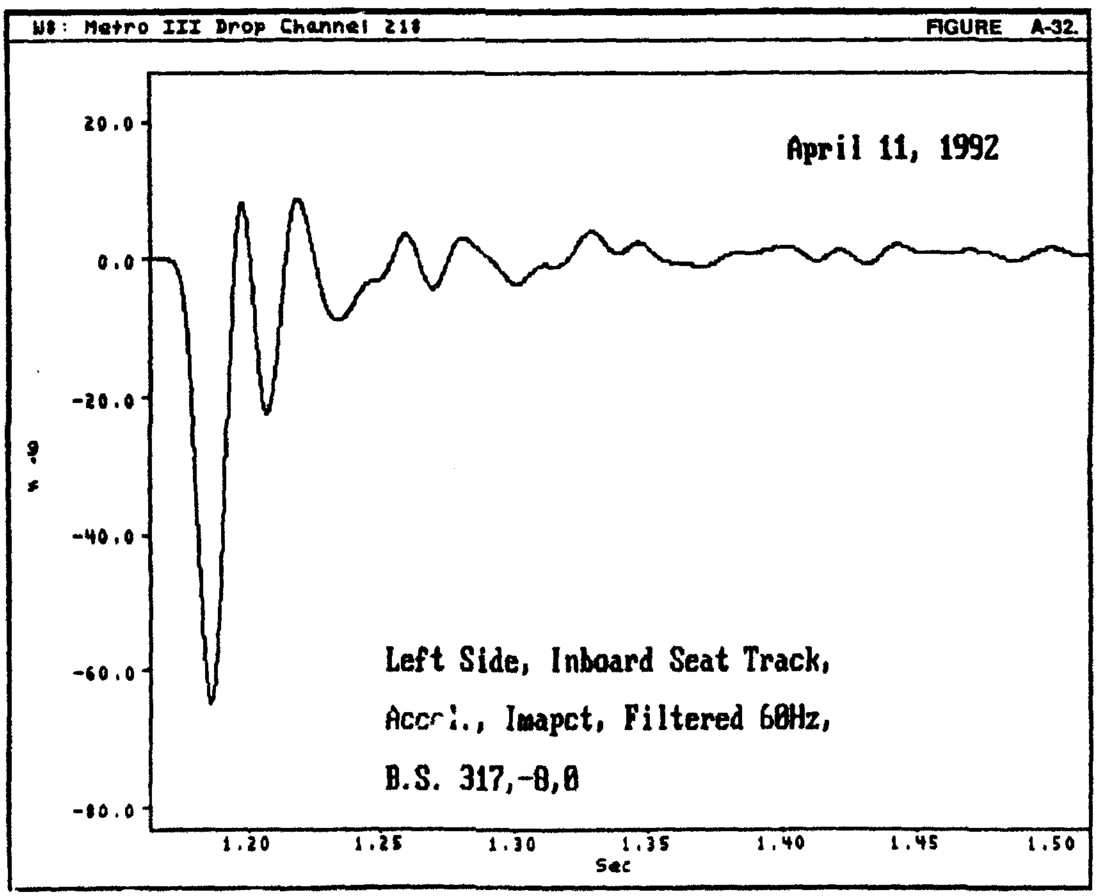


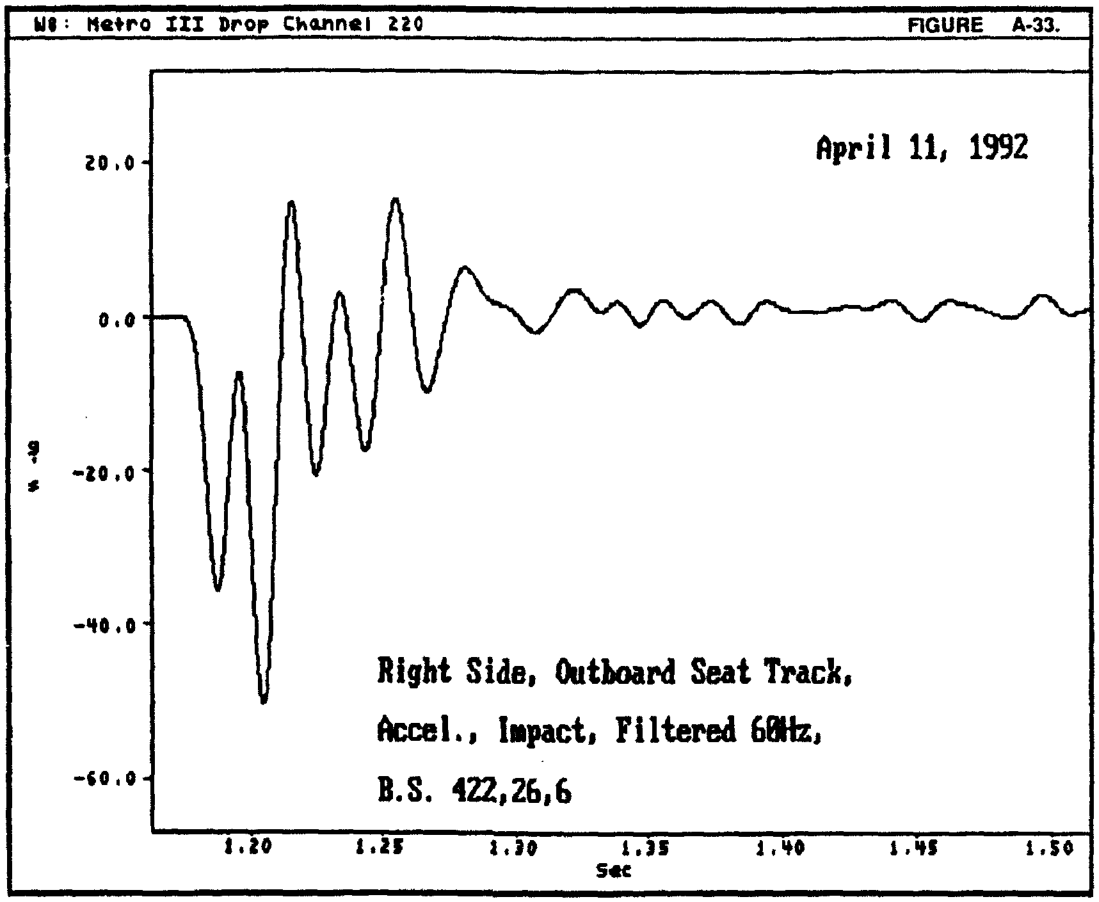
W8: Metro III Drop Channel 215
FIGURE A-28.
April 11, 1992
Right Side, Inboard Seat Track,
Accel., Imapct, Filtered 60Hz,
B.S. 317,8,0
g's
20.0
0.0
-20.0
-40.0
-60.0
-80.0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

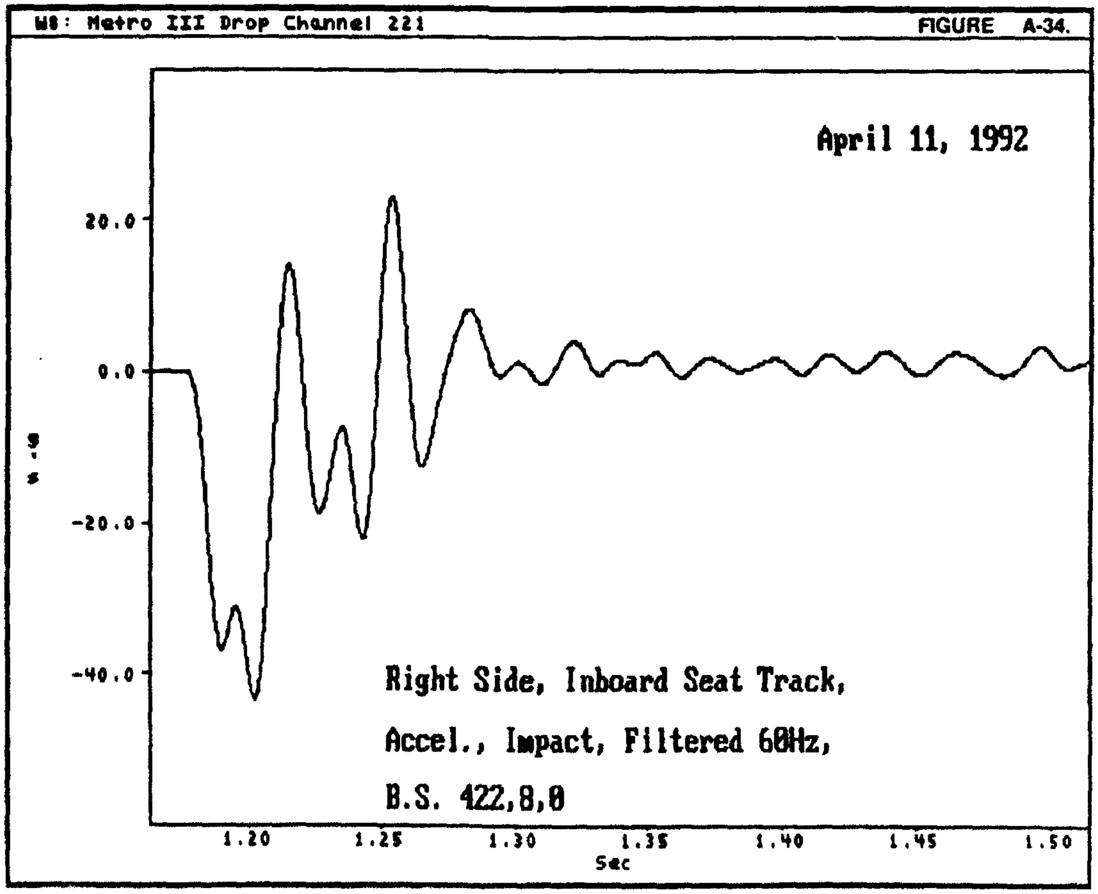

W8: Metro III Drop Channel 216
FIGURE A-29.
April 11, 1992
Left Side Wall, Accel.,
Impact, Filtered 60Hz,
B.S. 317,-32,30
20.0
0.0
-20.0
-40.0
-60.0
g's
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

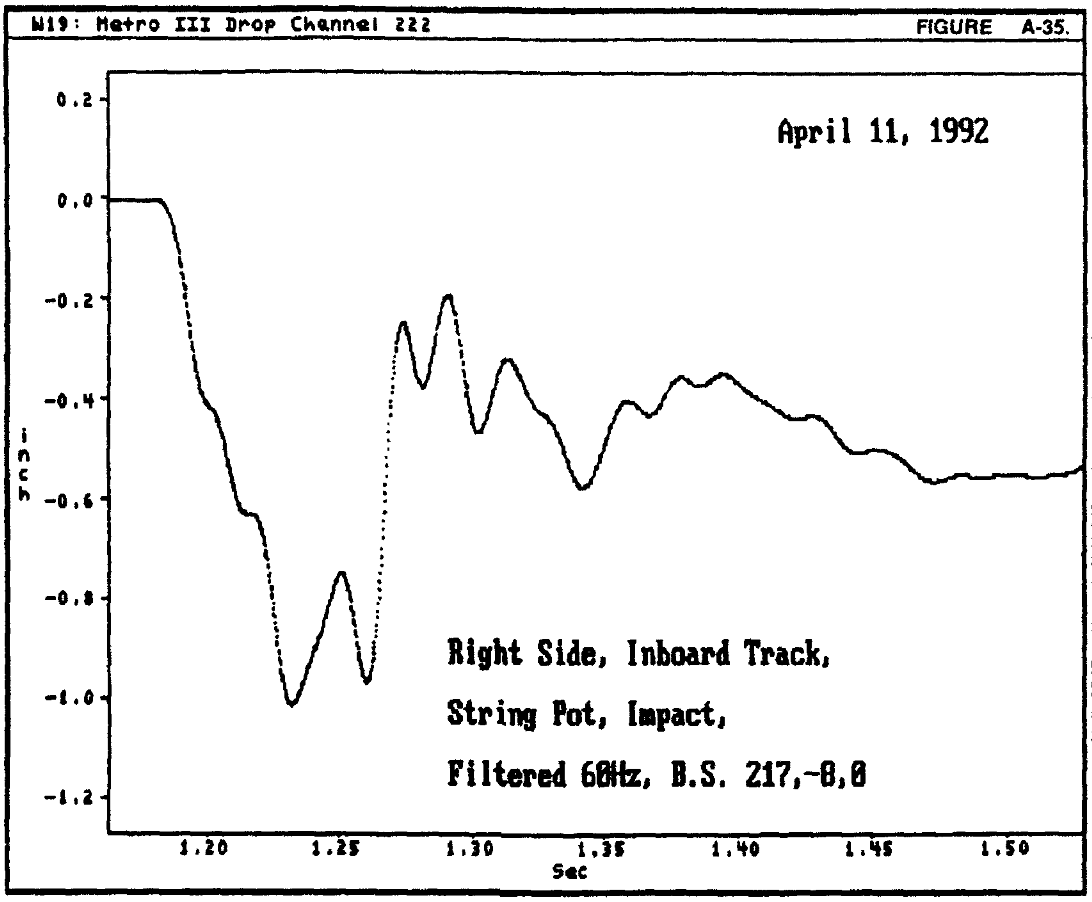

W8: Metro III Drop Channel 217
FIGURE A-30.
April 11, 1992
Left Side, Outboard Seat Track,
Accel., Impact, Filtered 60Hz,
B.S. 317,-26,6
20.0
0.0
-20.0
-40.0
-60.0
g's
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec


W8: Metro III Drop Channel 217
FIGURE A-31.
20.0
0.0
-20.0
-40.0
-60.0
g's
April 11, 1992
Left Side, Outboard Seat Track,
Accel., Impact, Filtered 60Hz,
B.S. 317,-26,6
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

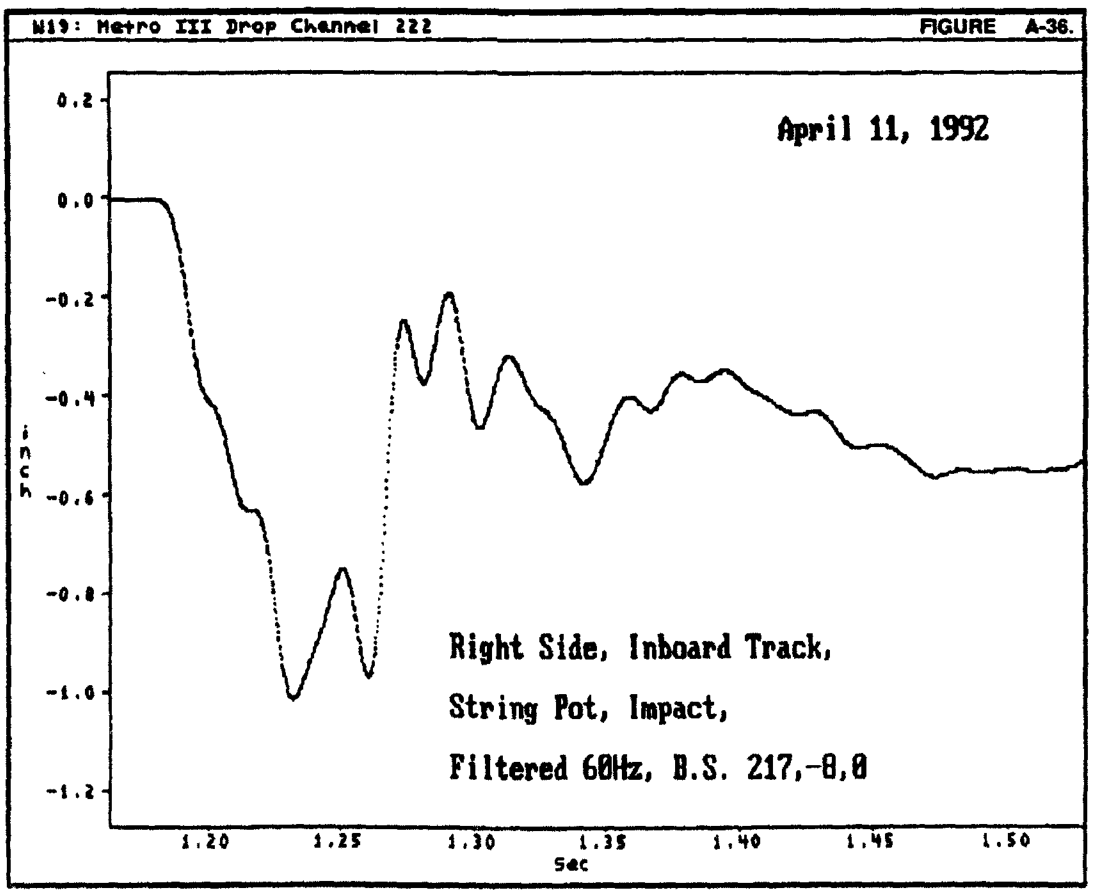

W8: Metro III Drop Channel 218
FIGURE A-32.
20.0
0.0
-20.0
-40.0
-60.0
-80.0
g's
April 11, 1992
Left Side, Inboard Seat Track,
Accel., Imapct, Filtered 60Hz,
B.S. 317,-8,0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec


W8: Metro III Drop Channel 220
FIGURE A-33.
April 11, 1992
20.0
0.0
-20.0
-40.0
-60.0
g's
Right Side, Outboard Seat Track,
Accel., Impact, Filtered 60Hz,
B.S. 422,26,6
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

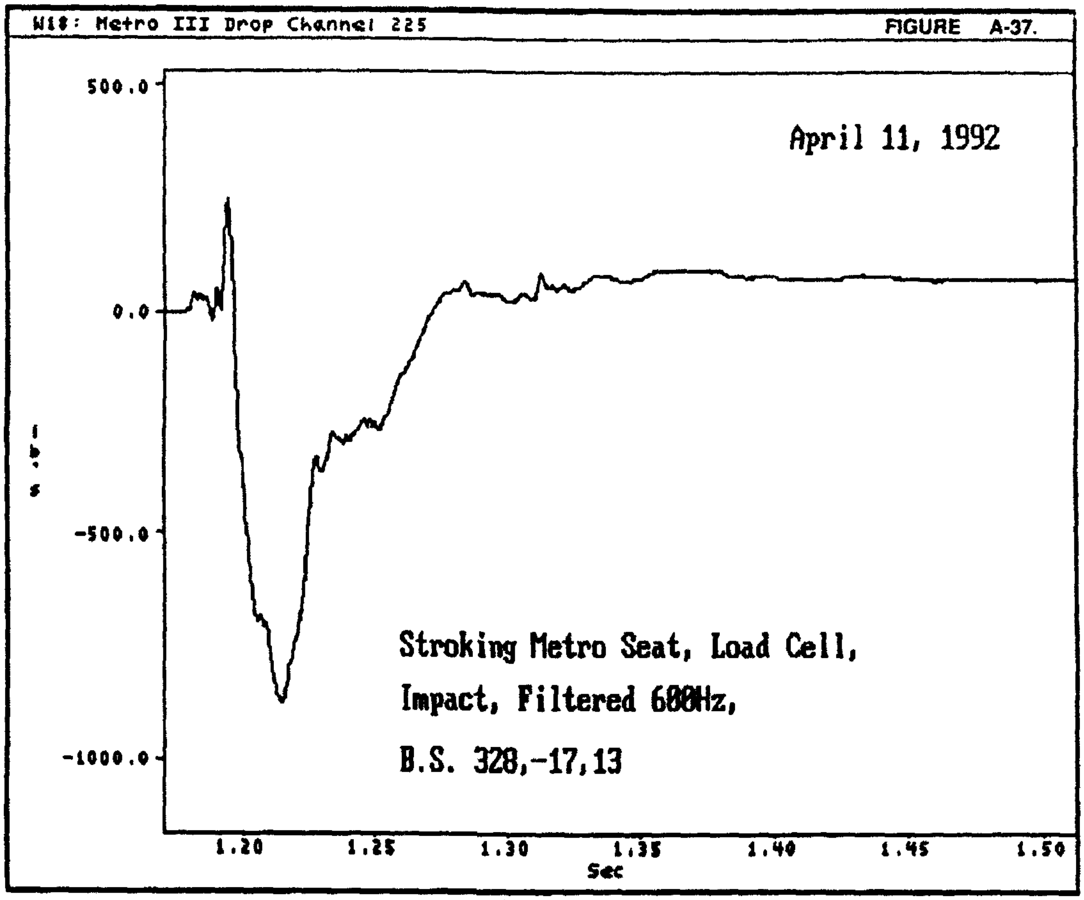

W8: Metro III Drop Channel 221
FIGURE A-34.
April 11, 1992
20.0
0.0
-20.0
-40.0
g's
Right Side, Inboard Seat Track,
Accel., Impact, Filtered 60Hz,
B.S. 422,8,0
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec

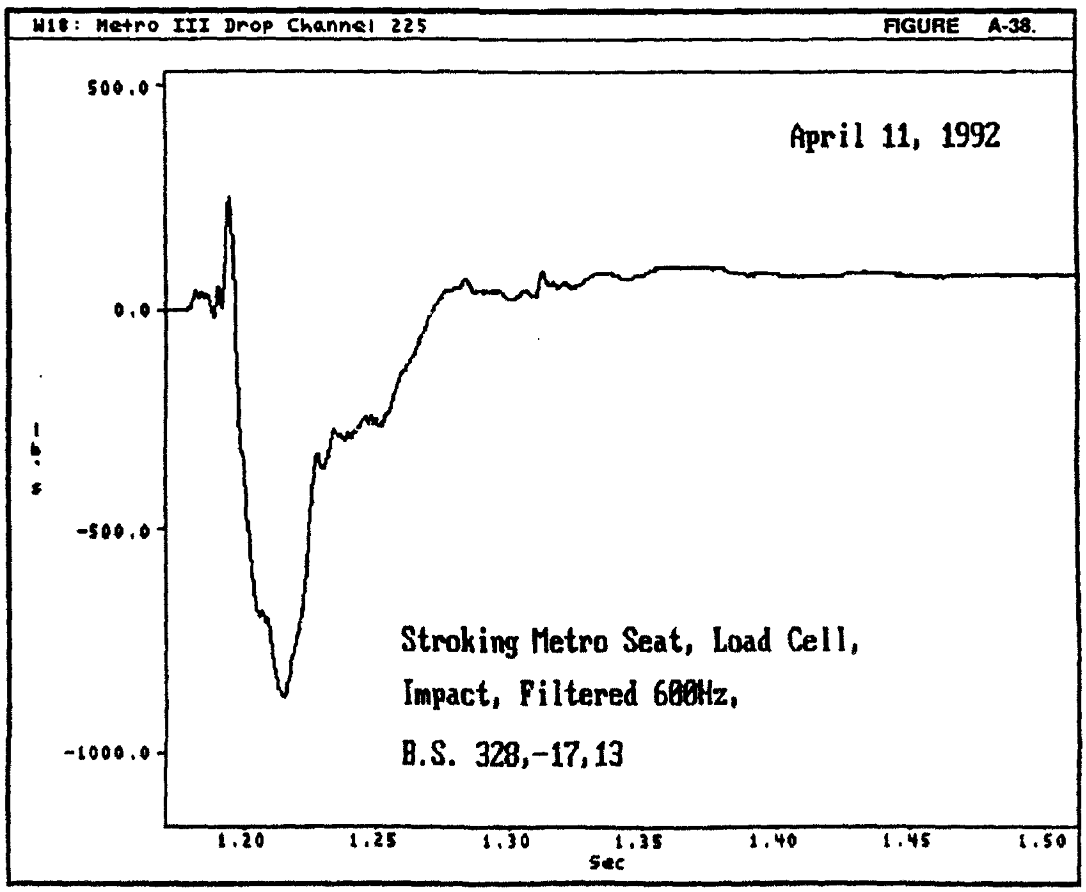


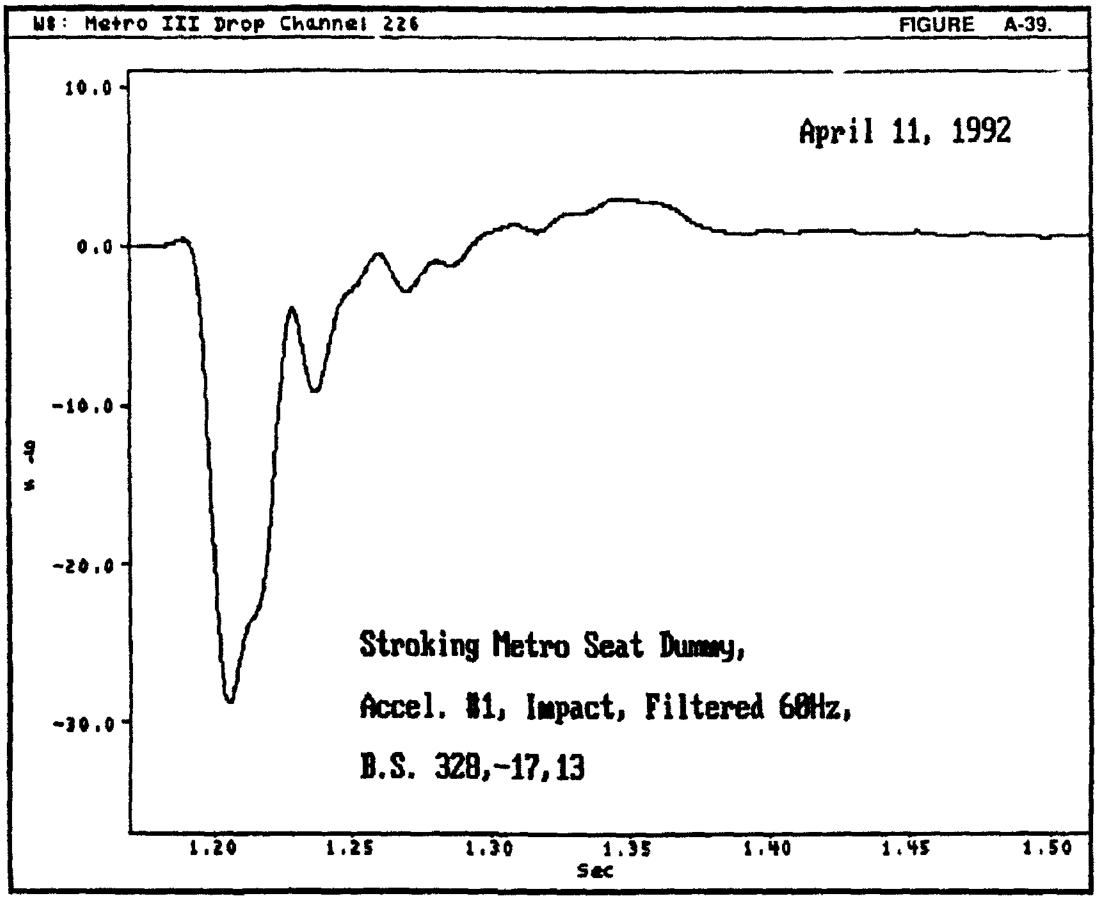
W19: Metro III Drop Channel 222
FIGURE A-35.
April 11, 1992
Right Side, Inboard Track,
String Pot, Impact,
Filtered 60Hz, B.S. 217,-8,0
inch
Sec
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
1.20
1.25
1.30
1.35
1.40
1.45
1.50

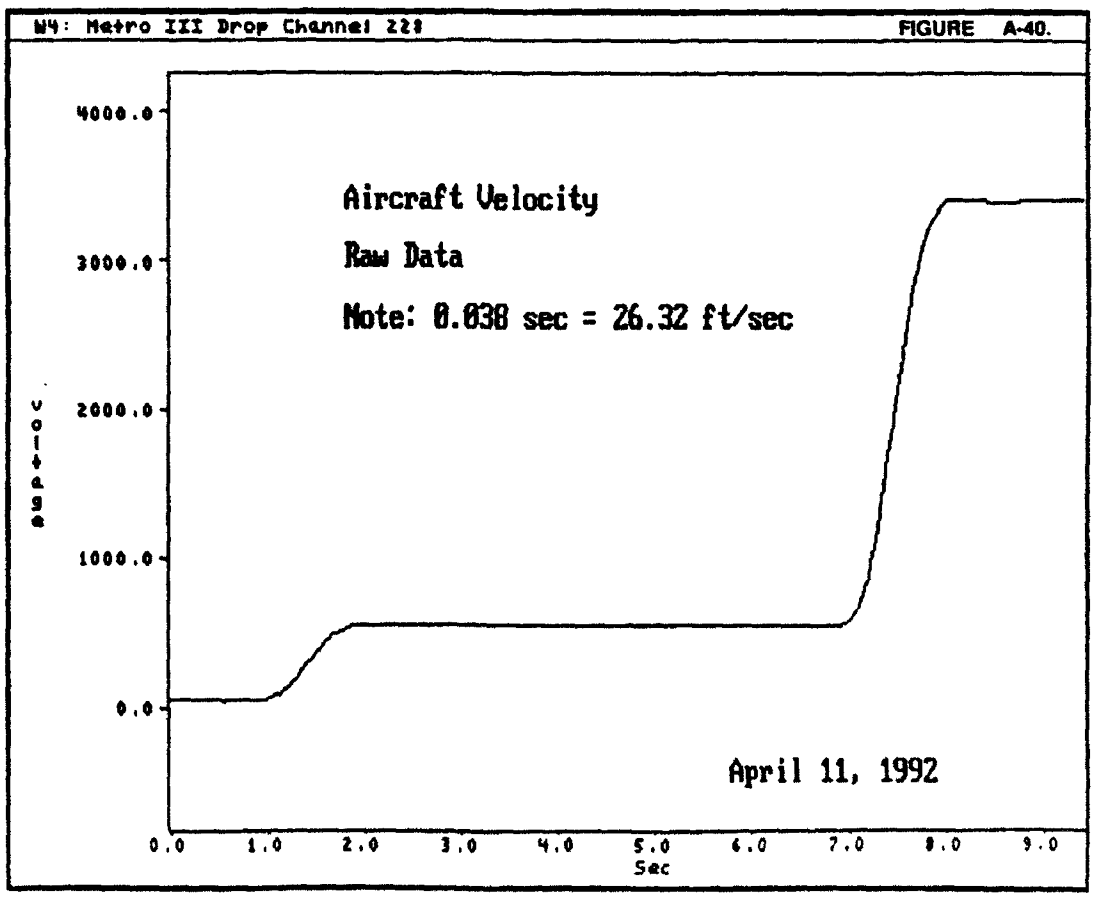


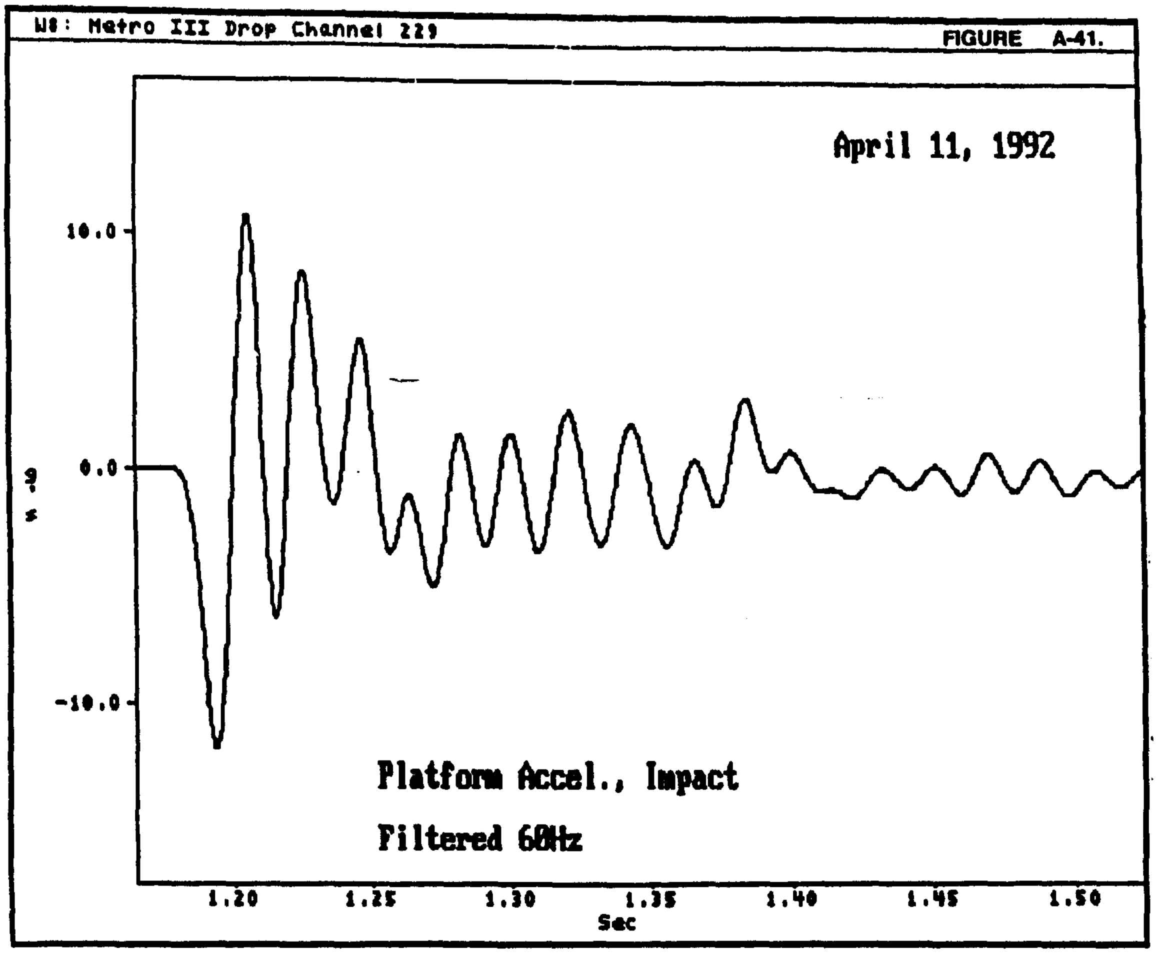
W19: Metro III Drop Channel 222
FIGURE A-36.
April 11, 1992
Right Side, Inboard Track,
String Pot, Impact,
Filtered 60Hz, B.S. 217,-8,0
inch
Sec
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
1.20
1.25
1.30
1.35
1.40
1.45
1.50


W18: Metro III Drop Channel 225
FIGURE A-37.
500.0
0.0
-500.0
-1000.0
lbs
April 11, 1992
Stroking Metro Seat, Load Cell,
Impact, Filtered 600Hz,
B.S. 328,-17,13
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec


W18: Metro III Drop Channel 225
FIGURE A-38.
500.0
0.0
-500.0
-1000.0
lbs
April 11, 1992
Stroking Metro Seat, Load Cell,
Impact, Filtered 600Hz,
B.S. 328,-17,13
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec


W8: Metro III Drop Channel 226
FIGURE A-39.
10.0
0.0
-10.0
-20.0
-30.0
g's
April 11, 1992
Stroking Metro Seat Dummy,
Accel. #1, Impact, Filtered 60Hz,
B.S. 328,-17,13
1.20
1.25
1.30
1.35
1.40
1.45
1.50
Sec


W4: Metro III Drop Channel 228
FIGURE A-40.
4000.0
3000.0
2000.0
1000.0
0.0
Voltage
Aircraft Velocity
Raw Data
Note: 0.038 sec = 26.32 ft/sec
April 11, 1992
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Sec



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